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WEAPON SYSTEM-SPECIFIC OCCUPATIONAL ANALYSIS

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13. ABSTRACT *(Maximum 200 words)*

Two on-going research approaches to developing methods for providing weapon-system specific task-level data for use in manpower, personnel, and training programs are described. One is directed at the mapping of data collected in occupational surveys (OSMs) and data from the Maintenance Data Collection System (MDCS). The other approach considers the use of MDCS data to develop weapon system-specific tasks for use in future occupational surveys of Air Force Specialties (AFSs). A Semantic-Assisted Analysis Technology (SAAT), developed to link historical data, correctly mapped up to 85% of OSM and MDCS data. The SAAT is a microcomputer-based system that semantically maps OSM tasks with MDCS Action Taken Codes and Work Unit Codes. For developing OSM job inventories for future use, four conclusions are warranted: military standards exist for use in generating and organizing system-specific OSM tasks from MDCS data; present microcomputer technology can be modified to extract relevant MDCS data; a single inventory should ber used for data collection to facilitate analysis using the Comprehensive Occupational Data Analysis Programs; and task data should be collected from job incumbents at generic and specific levels of task description to provide data needed by the varienty of users of OSM data.

14. SUBJECT TERMS

Air Force Specialty (AFS)	Consolidated Aircraft Maint System	Occupational Survey Method
ASCII CODAP	Semantic-Assisted Analysis Tech	Specialty Knowledge Tests
Action Taken Code (ATC)	Logistics Composite Model	Weapon System-Specific

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PREFACE

This research was performed in support of the Manpower and Personnel Research Division, Human Resources Directorate, Armstrong Laboratory, Brooks Air Force Base, Texas. The research effort supported the integration of manpower, personnel, and training (MPT) planning for Air Force weapon systems. The purpose of this research is to enhance technologies for increasing the specificity of data available from maintenance job inventories and further development of software to assist in weapon system-specific analyses of work performed in maintenance specialties.

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WEAPON SYSTEM-SPECIFIC OCCUPATIONAL ANALYSIS

I. INTRODUCTION

This report is the third of a series considering technologies for enhancing methods which identify, describe, and analyze the work performed in maintenance specialties. The research reported is directed specifically at increasing the specificity of data available from maintenance Job Inventories, developed and administered by the USAF Occupational Measurement Center (USAFOMC), that constitute the occupational survey task data base (OSM). There were two goals of the research.

The first goal was to test and recommend enhancements of Semantic-Assisted Analysis Technology (SAAT) procedures for mapping existing task data, from past occupational surveys of Air Force Specialties (AFS), and weapon system-specific task data, from existing maintenance data bases (primarily the Maintenance Data Collection System (MDCS)). The objective of this effort was to capitalize on the large amount of OSM data available and to associate the job survey personnel and training data more clearly with specific weapon system components.

The second goal was to identify and describe alternative strategies and assess their feasibility for developing and administering future USAF Job Inventories. These inventories will include weapons system-specific maintenance tasks and data based on MDCS Work Unit Code (WUC) equipment identification or nomenclature and Action Taken Codes (ATC).

An approach centered around the development and use of a single computer-generated Job Inventory from MDCS WUCs and ATCs for collecting data from AFS job incumbents is proposed. Use of a single inventory is (1) more cost effective; (2) essential for and can be employed in both mail and computer administration; (3) provides job incumbents opportunity to respond to each system they maintain; (4) facilitates analysis using the Comprehensive Occupational Data Analysis Programs (CODAP); (5) provides for comparability of task factor information across aircraft for which an AFS has responsibility; (6) provides task data not specific to any single aircraft (generic data) for users who require this kind of task data; and (7) provides equipment-specific task data by specific aircraft for users needing more detailed task data. The approach is based on the use of two levels of task description to which job incumbents respond. Responses to WUC-specific tasks would provide equipment-specific task data by aircraft. Generic task data would serve two purposes: they are the key to aggregation of data across the work of an AFS, and they provide a higher level of job-task information.

The proposed approach derives from careful consideration of the following factors: background and requirements; task characteristics essential for collection of reliable job-task data; present occupational survey methodology and practices; the scope of the requirement for WUC-specific tasks; user data requirements; and sources for developing both specific and generic tasks. These factors are discussed in the following sections.

II. BACKGROUND

This section describes the requirements for more weapon system-specific data and the research to date to provide for mapping occupational survey and MDCS data as well as a prototype methodology for developing occupational survey task lists from maintenance data.

Requirements

The present operational program for Air Force (AF) occupational analysis involves the use of job inventories in AF-wide occupational surveys. Job incumbents identify the tasks they perform in their current jobs, rate the relative amount of time they spend performing each of the tasks, indicate what equipment they work on, and also provide a variety of task factor, demographic, and personnel data. The collective results of these surveys comprise the only AF data base in which personnel information is linked to specific task data, providing unique capabilities for integrating personnel and training planning. The present products have significant impacts as personnel and training decision aids in establishing aptitude requirements, determining training priorities, and confirming the need for Air Force Specialty (AFS) shreds or specialized training. With major changes and consolidations being planned for Air Force maintenance specialties, the survey data base is an immediate source of vital information needed for AFS restructuring.

Especially important is the need for a data base to aid in making personnel and training decisions on AFSs needed for new weapon systems. To serve this purpose and to be compatible with comparability analysis used in the design of a new system (Mayer & York, 1974), the job survey data must be able to provide job-task data specific to each weapon system--data uniquely relatable to specific systems and weapon systems components. While this capability now exists to a large extent for a few AFSs which relate to a single weapon system, all or nearly all job inventories contain some "generic" task statements covering a set of related tasks with varying losses of specificity. This situation is especially true for AFSs covering multiple weapon systems because of the need to stay within the practical limits of length for a mail survey instrument.

The problem is that generic task statements may obscure significant differences in task skill and knowledge requirements, learning times, and other factors essential for optimal AFS structuring decisions. In principle, the requirement for more specific task data can be approached from "past and future" directions as recommended in the first report of this series (Driskill, Boyle, & Garcia, 1986).

Maintenance data from the MDCS or Logistics Support Analysis Record (LSAR) information for emerging weapon systems and equipment, can be mapped to past occupational survey data. This mapping will satisfy task specificity requirements from historical data. The mapping can provide the level of specificity desired at both the system and component level. It is resource intensive and time consuming to cross-walk occupational survey tasks and data to other maintenance data sources manually. Thus there is a need for a less costly mapping process.

Weapon system-specific task data from **future** occupational surveys could be obtained more efficiently if the tasks in Job Inventories used to collect job data are based on weapon system-specific task data in MDCS (or LSAR for emerging systems) or are precoded to WUCs. Detailed component, subsystem, and system information at each weapon system WUC nomenclature level can be provided. Methods for developing these kinds of tasks need to be identified and tested.

In addition to providing more specific job data for use in the weapon system acquisition process, improvement of inventory development technology can be anticipated. The present inventory development technology was developed during the mid-1960s when Air Force Specialty (AFS) structure was much less complicated, especially maintenance specialties in which fewer aircraft and less equipment were common place, and before the multiplicity of manpower, personnel, and training uses of task data were realized. As more weapon systems and associated equipment were included in the work of the various AFSs, inventory development and survey technology, except for CODAP capabilities, did not keep pace. There simply have been no techniques for accessing and utilizing maintenance task information in the MDCS or the LSAR, which can be extremely useful sources of data for Job Inventory development.

As a result of specialties becoming more complex, tasks became more generic, except for the weapon system-specific AFSs for the more recent weapon systems (F-111, F-15, F-16, B-1). Even these dedicated AFSs are limited to select subsystems (e.g., avionics) and much of the work on the remaining systems (e.g., fuels, environmental, electrical) has been incorporated in general specialties covering **all** aircraft.

A problem is the scope of generic AFS. Table 1 shows the number of AFS for which generic task statements must be generated during job inventory development for weapon systems, missiles, and communications-electronic equipment. As can be seen, the number

of generic AFS is considerably larger than system-specific AFS.

Table 1. Number of Generic Maintenance Air Force Specialties

Kind of AFS	N*
Generic maintenance (all aircraft covered, no shreds)	23
Generic AFS, command specific shreds	3
Generic plus aircraft specific shreds	6
Other generic AFS for missiles and communications-electronic	22
Subtotal of generic AFS	**54**
Aircraft specific	8
Total maintenance AFS	**62**

*Numbers obtained from counting AFS on the Airman Classification Chart, dated-- 31 October 1988.

As a general rule, under present OSM inventory development procedures, specific tasks are easily described for equipment, missile, or aircraft specialties in which only one or a very few equipment items are included. Some of the AFSs resulting from RIVET WORKFORCE have been formed with this idea in mind. Use of MDCS task information available for each of these weapon systems should make specific task lists even more easily developed.

Generic tasks are the only inventory development option under the present OSM technology, for AFS having multiple equipment, missiles, and weapons systems. The generality of task statements, however, can cause job incumbents to misunderstand the intent of the statement as well as result in the development of tasks which overlap with other tasks in the inventory.

Furthermore, research value exists in the potential for identifying a methodology that is the basis for the development of Job Inventories for nonmaintenance specialties. These specialties usually are described by generic tasks that provide much less information than more specific tasks could. The development of a taxonomy describing the structure of a specialty and locating and using automated data bases with information relevant to the work of a specialty would be extremely useful for developing task lists for nonmaintenance specialties.

Status of Research on Weapon System-Specific Tasks

Two previous reports have addressed the question of mapping OSM data and other maintenance data sources and developing weapon system-specific task lists. In the first report (Driskill, Boyle, & Garcia, 1986), occupational survey (OSM) data, MDCS data, the LSAR, and Logistic Composite Model (LCOM) input and output were described in detail, and the compatibility of the data for crosswalking among the various sources was assessed. Briefly, each of the data sources provide maintenance task data, although the LSAR is from a developmental perspective. The data in the systems are complementary. Unfortunately crosswalking between OSM data and the other sources is limited to verbal linkages. When the first research was reported, the only linkage possibility was manual mapping of OSM to MDCS and the other maintenance data. The crosswalking between MDCS and LCOM, that occurs in the preparation of input data to the LCOM in which WUCs from the MDCS are key data elements, was identified. Although similarity exists between LSAR and the MDCS, some problems in mapping LSAR to MDCS were identified, primarily having to do with variations in WUCs. Considerable manual mapping would thus be required. This report recommended semantic mapping as a possible solution and estimated that perhaps as much as 60 percent of the mapping could be accomplished using a microcomputer-based semantic-assisted analysis methodology.

The second report (Driskill, Weissmuller, and Staley, 1987), had two objectives. The first objective was the development of a microcomputer-based methodology for semantically matching tasks in the OSM data base with the tasks in the MDCS. Occupational survey tasks invariably consist of a verb (an action taken) and an object (the "thing" acted upon by the verb). The MDCS tasks consist of the verbal translation of the action taken codes (ATC) used in the maintenance of various WUC equipment items of a given weapon system (the objects of the actions taken). MDCS actions taken generally parallel the verbs employed in OSM inventory tasks while the MDCS WUC equipment identification is semantically similar to and parallel the task-verb objects in inventory tasks. As inventory tasks become more generic (that is, tasks intended to describe the work performed on multiple systems), OSM inventory task objects and WUC equipment identification terminology often become less semantically similar.

In the Semantic-Assisted Analysis Technology (SAAT) prototype (briefly described in a later section) developed to accomplish the mapping, MDCS maintenance data for a weapon system and OSM data for a given AFS are downloaded to a microcomputer. A series of programs are then employed to produce a map of semantically similar OSM and MDCS tasks. Subject matter experts (SMEs) verify and edit the microcomputer-generated matching and map any unmatched items.

The initial tryout of the SAAT prototype involved four AFSs which perform on-equipment maintenance on the F-16. This SAAT mapping eliminated from 65 to 85 percent

of the manual matching that would otherwise be required. This exceeded the initial estimate of the SAAT efficiency by 5-25 percent. Further, SMEs required only about two hours to complete the mapping, thus reducing the resource intensiveness that would be associated with a completely manual process. Three of the four AFSs covered three weapon systems (F-111, F-15, F-16) while the fourth AFS was generic covering all aircraft. Of particular interest was the fact that many of the unmatched items for each AFS resulted from the generic statements used to describe the OSM inventory task-verb objects.

The second objective of the study was the development of a prototype microcomputer system to produce a component-specific OSM task list based on MDCS WUC data for a single weapon system. The ease of producing such a task list, using a microcomputer-based methodology, for an AFS was demonstrated. An inventory of tasks for an AFS whose incumbents perform on-equipment maintenance on the F-16 was produced from MDCS maintenance data for use by the SAAT. A series of programs produces a task list consisting of the MDCS ATC (task verb) and the WUC equipment identification items (task object) on which the actions are taken. Included for each item are statistical data showing such information as the frequency of the action taken on the WUC equipment identification object, the average time, and the average crew size. No tasks were produced from the Support General or Inspection Codes, although such tasks can be used in the same set of programs.

Obviously, such a task list represents only the maintenance tasks performed, which is a part of the total tasks performed by personnel in the AFS. Management, supervisory, and training tasks are not available in the MDCS and must be added to the Job Inventory. Similar system and component-specific task lists for any **single** weapon system (or missile or communication electronics systems) can be produced for any maintenance (e.g., on-equipment, off-equipment, on-equipment non-airborne, etc.) performed on the system. The information pertaining to the type of maintenances, such as flightline (on-equipment) or shop (off-equipment), personnel from specific AFSs perform is essential in obtaining maintenance data tapes from the MDCS. Further, it is imperative that the MDCS data for aircraft be provided on separate data tapes because of the difficulty encountered in sorting the maintenance data when more than one aircraft data set are included on a single tape. On the MDCS data tapes, aircraft identification is readily identifiable **only for maintenance performed on the flightline.**

A method for developing Job Inventories for generic AFSs covering multiple weapon systems (or communications-electronics equipment or missile systems) from MDCS WUCs has not yet been developed. Development of these inventories is a far more difficult endeavor and will be covered in later sections of this report. Results of a further tryout of the production of single system-specific on-equipment task lists from WUCs for two AFSs working on the F-15 and one AFS on the B-1B will also be discussed. But, first, in the following sections, results of further tryout of the SAAT on two AFSs performing on-equipment maintenance on the F-15 will be described.

III. SEMANTIC-ASSISTED ANALYSIS TECHNOLOGY

This section briefly describes the Semantic-Assisted Analysis methodology and presents a discussion of important steps requiring analyst intervention in mapping MDCS action taken and work unit code equipment items to occupational survey tasks and data.

Description

Experience as well as previous research (Wagner, 1986) reveals that SMEs can manually map much of the MDCS data for an aircraft to many of the tasks in an occupational survey parallel to the MDCS data. Manual mapping is resource intensive and time consuming. The Semantic-assisted Analysis Technology was developed on the premise that a microcomputer methodology could be developed to reduce the workload associated with the manual mapping.

In any responsible data base management system, data are collected at what is considered to be a reasonable level of detail for the typical user. In the development of the MDCS, logistical users were identified, thus the data in the system has to do with the reliability and maintainability of equipment. For the OSM, personnel and training functions were envisioned as major users in its design and development, and the resulting data are collected and reported at a much broader but generally acceptable level of detail than in the MDCS. Time and cost typically preclude collecting survey data at the lowest level of detail desired by specific categories of users. Frequently other data base users are identified after design, development, and implementation, as in the case of the mapping survey and MDCS data. The problem, then, lies in developing some methodology which allows description of the data fields to be analyzed, decomposed, cross-referenced, and re-synthesized to yield estimates of data for different structures or levels of detail.

A key step in this process, particularly where different data bases are developed for different purposes and users, is a semantic interpretation of the descriptions themselves. In this context, "semantic interpretation" means developing a knowledge-structure (or schemata) which relates and organizes concepts into one or more taxonomies useful for the purposes at hand. The problem here lies in the fact that the same physical workspace may be described by very dissimilar taxonomies ("World Views") by different users (i.e., from different functional perspectives and goals). Each World View is composed of concepts which may be either references to physical objects (objective) or references to perceived relationships or states (theoretical). In addition, concepts are conveyed by tokens, such as words, phrases, abbreviations, or symbols, giving rise to confusion when different tokens (synonyms) can be used to indicate the same concept, or when a given token can mean or

imply different concepts depending upon its context (an equivocation). These types of interpretations can be made only by trained SMEs.

Two mapping approaches could be taken. The first, and most labor intensive, is to have SMEs meet, review the array of data, propose a taxonomy, and, for each data element, map it onto or associate it with entries in the taxonomy. The second approach is to preprocess all written materials by computer and have intelligent software create a tentative structure and mapping before the SMEs arrive.

The second approach has many advantages. First, the structure created will be reproducible with the rules used clearly defined. This step is facilitated if an existing structure is selected as a starting point, even if it is not the final structure employed. Second, this approach reduces the fatigue factor on the SME by performing the mechanical work they would have to do under the purely manual approach. Third, computer time is less expensive than SME time. Fourth, the computer will make mistakes in the mapping, but the SME's first job is to redline those errors which quickly demonstrates their value to the project and reinforces their active participation in this high-level decision-making. Fifth, SME recognition skills are better than their recall skills and, hence, progress is expedited in the initial phase. Finally, because they clearly have in mind what the objectives are (from the previous step), the SME can do a better job when they inspect "highly valued" items which are NOT currently mapped and allocate them to their proper places in the hierarchy.

The second approach is embodied in the Semantic-assisted Analysis Technology. In recognition of the inherent differences in the internal structures of the descriptions of OSM and MDCS tasks, automated cross-referencing in the development of the initial SAAT is based on key words or phrases (An enhancement which will incorporate "values" derived from OSM and MDCS data for these words or phrases will be proposed in a later section as a means of making SAAT more powerful and producing even better matches). While linguistic analysis is possible on OSM task statements, the MDCS system fundamentally separates verbs (actions taken) from objects and drops all references to actors (in OSM tasks, the actor is the assumed word "I" preceding each task statement).

Although processing of MDCS data is simplified, because the data are barren of theoretical content other than in verb choice, processing is confounded by the hierarchical nature of MDCS data and the lack of standardization in word order and abbreviations in WUCs. In the MDCS, each WUC is a hierarchically arranged 5-character code. Each aircraft system has a designated 2-character code which comprises the first two characters of the WUC (e.g., 51---, Instruments; 72---, Radar Navigation). The 2-character code is invariant across aircraft. The third character designates the subsystem; the fourth character, a sub-subsystem; and the fifth character, a sub-subsystem component part. On the F-15, for example, WUC 51EAB represents Instruments (51), Air Data Systems (E), Computer, Air Data AN/ASK-6 (A), CONVERTER, Frequency to Digital (B). The third, fourth, and fifth characters of the WUC vary across aircraft. Because of the hierarchial nature of the MDCS

information, an equipment item defined by the fifth character of a WUC is inherited by the fourth character, and so on, it is the starting point in the mapping process. An item defined at the third, fourth, or fifth character level has no meaning if it is not "read" in the context of the preceding characters. In the WUC illustrated above, the fifth level item CONVERTER, Frequency to Digital, can only be interpreted in light of the preceding characters showing that the Converter is a part of the Air Data Computer in the Air Data Systems of the F-15 Instruments System.

Semantic-Assisted Analysis Technology, Sources, Processing, and Output

Figure 1 provides a conceptual description of the sources and data displayed in the final mapping of OSM and MDCS data and shows the two sources of data that are mapped. Presently SAAT, MDCS data are obtained from two sources: the B-4 Master File, which contains a complete listing of the WUCs and Equipment Identification for a given aircraft (or missile or communications-electronic equipment); and a MDCS data tape containing the actual aggregated force-wide maintenance records (as reported on-site by workers using Core Automated Maintenance System (CAMS) or manually on AF Form 349) for the given aircraft for a specified period of time. The MDCS Equipment Identification (that is, the names of the equipment items) is in abbreviated form, the description of the equipment names being limited to a total of 19 characters. As a part of the processing requirements, the abbreviated titles are fully expanded to reflect the complete title. OSM data are retrieved from the occupational survey data base for the given AFS. All sets of data are downloaded from the Air Force Human Resource Laboratory (AFHRL) Sperry 1100/82 to an AT compatible microcomputer.

In addition, to obtaining the MDCS data tapes, the analyst should also obtain a copy of the Work Unit Code Manual for the aircraft of interest and a copy of the USAF Job Inventory for the AFS of interest. An aircraft WUC Manual is a Technical Manual under the -06 Technical Order series, and is available from the Air Logistics Center having maintenance responsibility for the aircraft of interest. The WUC Manual is extremely useful for reference purposes throughout the mapping process. In many cases, the abbreviated titles in the B-4 Master File are provided in more fully-spelled out form, thus facilitating the expansion of the titles necessary in the SAAT.

A third information source, which provides a matching of AFS with the WUC used in maintaining the aircraft of interest, is required as a basis for the mapping of the data bases. To date, the Percent Contribution Report provided by HqTAC/XPMS has been the source, since Tactical Air Command aircraft have been used in testing SAAT. This document, an output of the Logistics Composite Model (LCOM) used in manpower planning, usually provides the WUC to the third character level for an AFS for those WUCs for which an AFS is to receive workload credit.

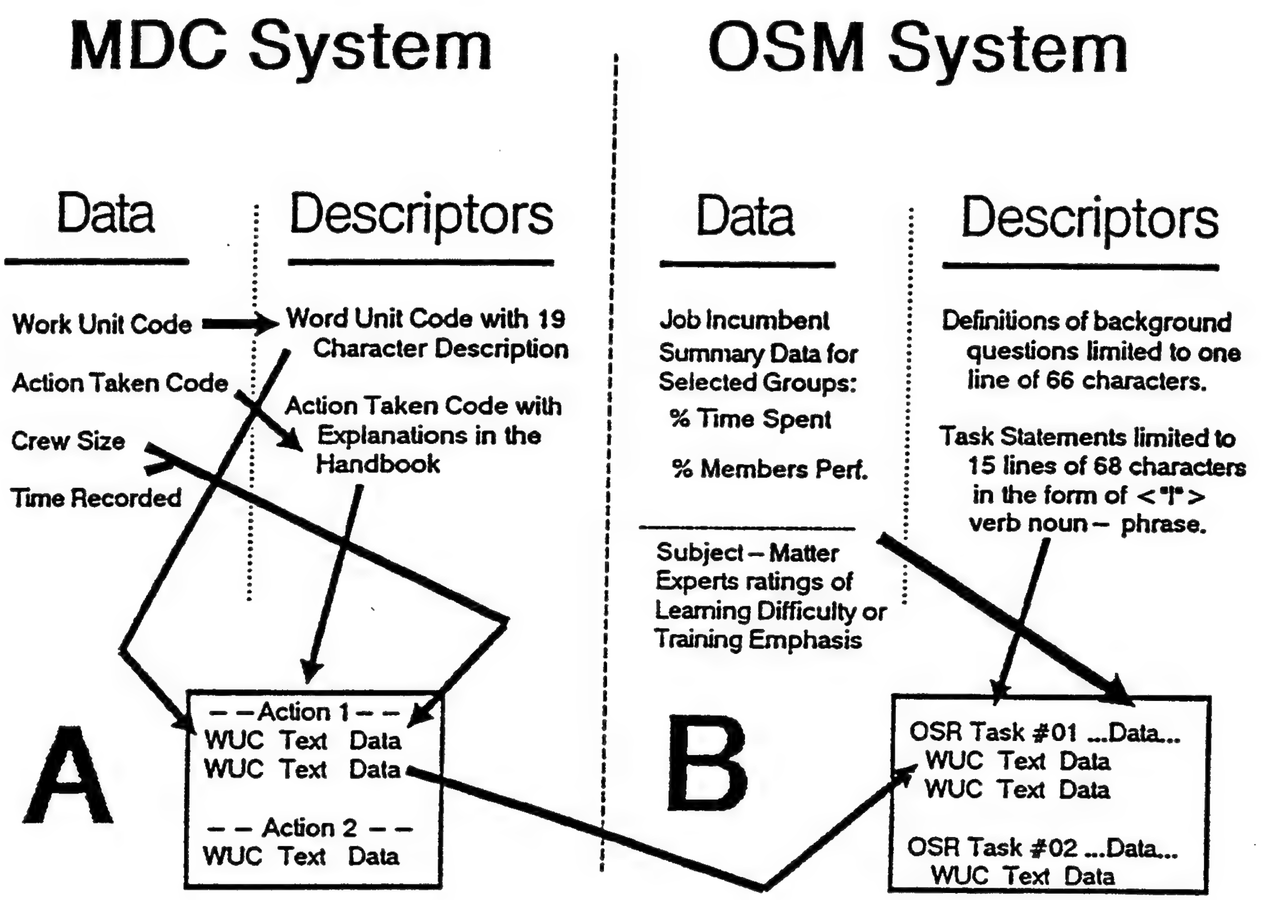

__Figure 1__. Data Sources.

At present, the only readily available source of WUC-AFS crosswalk information resides at Aeronautical Systems Division, Tactical Air Command, Military Airlift Command, and Strategic Air Command LCOM agencies. Table 2 shows the systems for which the WUC-AFS crosswalk information is available upon request.

Table 2. Systems for Which LCOM WUC-AFS Data Are Available

Location	Systems
Aeronautical Space Division	Advanced Tactical Fighter, C-17, LANTIRN
Military Airlift Command	C-130 E and H, C-141, C-5, AC-130, MC-130
Strategic Air Command	KC-135R
Tactical Air Command	F-15, F-16, F-4, F-111, E-3, A-10

(Information extracted from AIR FORCE CROSSWALK, 1989, p. 1-7)

For other systems, the sources at present are limited to SME interview or survey or through accessing base-level CAMS data at bases maintaining the aircraft of interest. CAMs replaces manual reporting of maintenance work. At base level, CAMS consolidates the AFS of workers with maintenance records that include WUCs. Approximately 40 percent of the Air Force bases, for which funds for the automated system have not been allocated, are still operating under the manual system of reporting maintenance, using AF Form 349. By approximately the end of FY 1991, all bases are expected to have converted to CAMS reporting. The proposed Air Force CROSSWALK Project, if completed, could provide immediate access to the required WUC-AFS mapping information, since it is proposed that a large part the Project will rely on base-level CAMS reporting (AIR FORCE CROSSWALK, 1989). Information from surveys or interviews and CAMS are potentially the best sources of information for use in SAAT because WUC-AFS information is more precise than is found in the LCOM information. For management engineering use, WUC identification at the 3-digit level is adequate, but is inadequate for SAAT mapping. The importance of precise WUC-AFS crosswalk data can be noted in a later section reporting the results of the latest mapping of OSM and MDCS data.

The actual SAAT mapping is based on an expansion of the abbreviations used in the 19-character description (equipment identification) of the WUCs in the B-4 file and the verb objects in the OSM task statements. MDCS and OSM statements are cross-matched based upon the use of common words, phrases, or concepts (tokens).

Cross-match candidates are evaluated within the context of knowing the information value of the common words, phrase, or concepts based on their frequency of occurrence. In the processing, all related words, phrases, or concepts are replaced with a common token, requiring analyst intervention in resolution of a small number of items that the microcomputer programs cannot resolve. The number requiring intervention varies by WUC by aircraft, because of the kind of abbreviations employed. Problems encountered in this replacement process include abbreviations, acronyms, hyphenations, parenthetical expressions, compound words, and contexts.

Once the related words are replaced, the next step requires determination of the information value of common tokens. Information value is established by identifying a subset of statements of interest and comparing token occurrence frequency inside the set to their frequency outside the set.

The SAAT mapping process is described in detail in the SAAT documentation (Driskill, et al., 1987). This documentation provides instruction for the computer technician, and indicates where analyst intervention is required to make judgments about such items as abbreviations, hyphenations, and plurals. In these instances, the analyst is provided instructions about the judgments to be made. In most cases, the intervention consists of verifying changes suggested by the SAAT software.

Most of the work involved occurs in the preparation of the OSM tasks and MDCS "tasks" for matching. It is important to remember in this preparation effort that <u>the matching is based on the existence of tokens common to the two data bases</u>. The preparation of each of the data bases, therefore, focuses on the development of tokens (from the words, phrases, and concepts contained in the data bases) that will ensure the commonality necessary for matching to occur. For example, a token like <u>ACFT</u> in the MDCS will not match the token <u>AIRCRAFT</u> in an OSM task statement; <u>ANGLE OF ATTACK</u> will not match <u>ANGLE-OF-ATTACK</u>; nor will <u>GYROSCOPE</u> match <u>GYROSCOPES</u>. The objective, however, is not to <u>force</u> commonality, but to prepare the tokens in such a way that token commonality will be identified where it exists.

The SAAT includes microcomputer programs which accomplish the following actions:

1. Eliminating abbreviations

2. Eliminating dangling hyphens

3. Correcting misspelled words

4. Recovering missing outline levels (missing WUCs and equipment identifications)

5. Substituting acronym definitions at every occurrence of an acronym

6. Eliminating superfluous hyphens and parenthetical phrases in the text

7. Identifying and replacing plural forms of words

8. Manually identifying semantically parallel terms from microcomputer output provided for this purpose

9. Automatically collapsing references to semantically parallel terms.

The elimination of abbreviations used in the MDCS data base requires most of the time an analyst spends in the SAAT process. This step is crucial. The process expands the abbreviations used in the B-4 Master File WUC Equipment Identification (names of equipment entities) to their full titles. Each entity expanded in this step becomes a token used in subsequent mapping. In Figure 2, for example, the abbreviated entity ACFT is expanded to AIRCRAFT. It is especially important that each expansion is made in the context of the WUC in which the abbreviation appears. Most of the expansion difficulty lies in the lack of consistency of the abbreviations used across WUC Manual equipment identifications.

As previously indicated, sources for expanding the abbreviations are limited. Unfortunately, personnel who maintain the WUC manual for various aircraft are unaware of any fully expanded, unabbreviated listing of the WUC Equipment Identification items available. Thus, at present the best sources for expanding the abbreviations are the WUC Manual (-06), which also contains many abbreviations, and personal knowledge--either on the part of the analyst or through use of SMEs. Telephone contacts with SMEs have been especially helpful to resolve abbreviations that the analyst could not decode.

Work Unit Code Manual Abbreviation	Expanded Form
ACFT	AIRCRAFT
ACT	ACTUATOR
ADAPT	ADAPTER
ADI	ATTITUDE DIRECTIONAL INDICATOR
AIRSPED	AIRSPEED
ANL	ANALOG
AOA	ANGLE OF ATTACK

Figure 2. Example of Abbreviated Work Unit Code Expansion.

Although expansion of the abbreviations is the most time consuming step in the process, once the abbreviated equipment identifications in a B-4 file for an aircraft are expanded for use in mapping to task statements for one AFS, the process does not need to

be completed again when mapping other AFS to the aircraft. Enhancements will be suggested in a later section of this report that will reduce the work associated with expanding the WUC abbreviations effort.

Before matching can occur, four data screens must be applied to the OSM and MDCS data. The first screen, on OSM data, is based on the AFS job description to be used. This screen is necessary to identify the tasks performed by incumbents of the target AFS. A number of options are available for selecting the OSM job description to be used, such as descriptions based on time in service, skill level, job group (case or task clustering), major command of the personnel performing maintenance on the aircraft of interest, and task factor data. Since the application of the SAAT to date has been for AFS covering multiple weapons systems, the screen applied has been based on the percentage of incumbents performing tasks only on the aircraft of interest (e.g., F-15) and who possess 5-skill level duty AFS. In addition, tasks were screened to eliminate those for which no WUC could be anticipated (e.g., duties pertaining to directing and training) and for which the percentage of personnel performing was 15 percent or less.

Following the application of this screen, two additional screens are applied to the OSM tasks. First, through use of one of the microcomputer programs incorporated in the SAAT, tasks beginning with verbs that cannot be related to WUC action taken codes are eliminated (e.g., review, write, complete). Next, tasks containing the same object, although the object was preceded with different verbs, were consolidated. Object consolidation eliminates the requirement for SMEs to review tasks comprised of a series of tasks on the same object such as isolating malfunctions, operationally checking, adjusting, removing or replacing, or calibrating (same object). Instead, SMEs can respond to a single task representing the action taken on a given object. Significant SME time is saved. At this point, the action taken is unimportant; this information will be supplied from actual maintenance records in later mapping.

The screen applied to the MDCS data is based on the WUC-AFS crosswalk information, and is necessary to narrow the scope of the mapping to those WUCs used by personnel of the AFS of interest. The greater the accuracy of the WUC-AFS crosswalk screen, the greater the SAAT mapping potential.

Following the application of screens, SAAT mapping can be accomplished. The product of the mapping is a printing of mapped OSM and MDCS data in a booklet format. The booklet contains WUCs and associated nomenclature mapped beneath the OSM tasks. SMEs then use the booklet to verify and edit the microcomputer generated matching of OSM and MDCS tasks (see Figure 3 for a sample page).

After the SMEs review, a final listing of the mapped information (Figure 4) is produced. This list contains each task in the job inventory used, and shows the percentage of incumbents performing, percentage of time spent in performance, and task difficulty and training emphasis mean ratings. Immediately below each task is a listing of the ATC, and the WUC and Equipment Identification of each item that job incumbents work on in performing the task. MDCS summary data can also be shown for such items as frequency of maintenance, average maintenance time, and crew size.

The entire mapping process from acquisition of data tapes and downloading to a microcomputer through production of the final result of the mapping, is detailed in the software documentation. Computer technicians with experience in ASCII CODAP processing on the AFHRL computer system can follow the documentation. Analyst experience with task list development for aircraft maintenance specialties or knowledge of these specialties is desirable.

IV. MAPPING MDCS AND OSM DATA FOR AFS 452X1B and 454X3 WORKING ON THE F-15

Further testing of the SAAT was accomplished by mapping OSM tasks and data to MDCS data for two AFS maintaining the F-15. The overall objectives were, first, reporting of results of mapping OSM and MDCS data for AFS 452X2B, F-16 Avionics Instrument, and AFS 454X3, Aircraft Fuel Systems. Second, enhancements of the SAAT were to be identified for future development.

OSM-MDCS Data Mapping

Several questions arise concerning the mapping of MDCS-WUC and OSM data. They include:

1. What is the accuracy of SAAT mapping of OSM and MDCS task data and how much time is required for SMEs to verify and edit the SAT mapping?

2. What kinds of tasks present problems for SAAT mapping?

3. What is the SME interrater agreement on verification and editing?

4. What are the primary problems encountered by SMEs?

5. How accurate is the WUC-AFS crosswalk screening data obtained from the Percent Contribution Report from the LCOM system?

6. What enhancements of the SAAT will produce more accurate mapping and reduce processing and SME verification workload?

In the following paragraphs, the results of SME verification and editing of data mapped for the two AFS chosen, as well as observations made in the application of the SAAT, are described.

1. Mapping Accuracy. To verify the SAT mapping, two SMEs from AFS 452X1B and three SMEs from AFS 454X3 working on the F15A at Holloman AFB were utilized. Separate sessions were employed for each AFS. In the previous SME verification of mapping for the F-16, only one SME from each AFS was utilized. The first session, involving the two AFS 422X1B SMEs, was used partly to determine the best method of administration when more than one SME are involved.

The AFS 452X1B SMEs were instructed to review the mapping, checking the appropriate WUC under a task, and to write in any WUC that was not listed. While they were not instructed to work independently, the implication was that they should do so. Independent work is a necessary prerequisite for determining interrater agreement among raters. It soon became apparent, however, that they could not work entirely independently, because they consistently encountered problems with interpretation of task statements. As a result, the SMEs ratings were not entirely independent. A tenable assumption is that respondents to job surveys also have problems with interpretation of task statements.

For the second group of SMEs (those with AFS 454X3), similar instructions for verifying the SAAT mapping were provided. Again, SMEs were not instructed to work independently, but the requirement was implied. They were, however, asked to complete the first half of the mapping (through page 11 of 23 pages) at which time the administrators would check what they had done before they would continue. This process was used so that instructions or other matters could be clarified. These SMEs, also encountered task interpretation problems and asked if they could work together. This request was granted and the remainder of the list (about 75 percent remained to be accomplished) was completed by the SMEs with considerable discussion of the meaning of many of the tasks.

Including the time for providing administrative instructions, the first group of SMEs (AFS 452X1B) required one hour and 55 minutes to complete the verification of the SAAT mapping. The three AFS 454X3 SMEs who rated more than one-third more tasks than did the SMEs for the other AFS required two hours and 20 minutes to complete the verification. The question of agreement among raters is discussed below. It should be noted that in the previous test of SAAT mapping for the Fuels Specialty for the F-16, the SMEs working alone did not complete the verification and editing within the three hours allotted (Driskill et al., 1987).

Results of the SME verification and editing are shown in Table 3.

Table 3. Results of SME Verification of SAAT Mapping by Number of Tasks

	AFS 452X1		AFS 454X3	
Task Category	N	%	N	%
N tasks screened for matching	189	100.0	118	100.0
Not performed by AFS	7	3.7	7	5.9
Not performed on F-15	38	20.1	27	22.9
Not WUC-equipment tasks	0	0.0	19	16.1
AFS-WUC not provided by LCOM Percent Contribution Report	17	9.0	0	0.0

Table 3. (Concluded)

Task Category	AFS 452X1 N	%	AFS 454X3 N	%
Total unmappable tasks	62	32.8	53	44.9
Total mappable tasks remaining	127	67.2	65	55.0
Tasks matched, no WUC write-ins	**95**	**74.8**	**55**	**84.6**
Tasks matched, write-ins added	15	11.8	4	6.2
Tasks not matched, write-ins added	17	13.4	6	9.2

Several conclusions may be drawn from this table:

a. The SAAT successfully maps MDCS data to OSM data for a large percentage of tasks where mapping of an aircraft WUC is possible. Seventy-five percent of the mappable tasks in AFS 422X1B were accurately mapped by the SAAT without any SME additions of WUCs. For AFS 454X3, 85 percent of the tasks were mapped without any WUCs being added. Overall, of the WUC-mappable tasks, 87 percent of the AFS 422X1B tasks were at least partially matched by the SAAT. The percentage of partial match was 91 for AFS 454X3.

Since there were a number of tasks for which there was no possibility of mapping WUCs by the SAAT or by the SMEs, SAAT mapping efficiency was computed by comparing the number of matched tasks with the number of tasks for which mapping was possible. The total number of tasks screened (based on percent of 5-skill level incumbents working on the F-15) for mapping was 118 for AFS 452XB and 189 for AFS 454X3. Of the total tasks screened for each AFS, there was no basis for SAAT mapping of 62 tasks for AFS 452X1B and 53 tasks for AFS 454X3. The following criteria were applied to define whether a task was unmappable by SAAT:

(1) A task for which the AFS had no responsibility for performing was not mappable because the WUC screen did not permit WUCs used by the other AFS to enter the mapping process.

(2) A task that could not be performed on the F-15 was not mappable, because the WUC screen did not permit use of WUCs for other aircraft.

(3) If the task was generically described with no equipment-specific object (e.g., Perform red dye tests), there was no opportunity for mapping WUCs.

(4) If the WUC-AFS screen did not include WUCs that job incumbents in the AFS reported, because of inadequacy of the WUC-AFS crosswalk data that was the basis of the screen, no WUC was available for mapping.

There were four classes of mappable tasks:

(1) Tasks for which the SAAT mapped the acceptable WUCs without any additions.

(2) Tasks for which the SAAT mapped acceptable WUCs but the SMEs added other WUCs.

(3) Tasks for which all of the WUCs mapped by the SAAT were unacceptable and SMEs added correct WUCs.

(4) Tasks for which there was acceptable mapping by SAAT, but SMEs added WUCs that could not be located in the MDCS B-4 Master File. The added WUCs are, however, included in WUC Manual amendments which have not been added in the B-4 file.

b. A large number of OSM tasks could not be used for WUC mapping. Although the OSM tasks were screened to provide data on incumbents who indicated that they worked only on the F-15, 38 (20 percent) of the tasks identified for AFS 452X3B could not be performed on the F-15. For AFS 454X3, there were 27 (23 percent) such tasks.

In addition, 19 (16 percent) AFS 454X3 tasks did not relate to any WUC. This number is not unexpected, because the Fuels Specialty is one in which the methods, materials, or processes of work are more important than the actual equipment the action is taken upon (e.g., perform red dye tests). Inclusion of these tasks in the Job Inventory was done to reduce the number of tasks in the inventory.

c. For purposes of semantic matching, the WUC-AFS matching contained in the LCOM Percent Contribution Report can be expected to be inadequate for at least some specialties. There were 17 tasks (9 percent) of the AFS 452X1B tasks for which WUCs were not provided by the LCOM Percent Contribution listing.

2. Problem Tasks. Aside from the tasks that could not be used for mapping, because of missing WUCs (for whatever reason), there were tasks for which the SAAT did not map any acceptable WUCs. These were tasks that described multiple kinds of equipment or systems similar in some key characteristic or function in broad, general, or generic terms.

3. Interrater Agreement. In terms of methods of administration to multiple SMEs, it appears that in a single group, the better procedure is to permit the SMEs to confer. They are able to resolve differences of task interpretation and provide a more consistent verification and mapping. Furthermore, given the variance of the jobs that comprise a specialty (Driskill & Mitchell, 1979), it should be anticipated that there will be lack of understanding of the tasks as well as lack of knowledge of the WUCs appropriate to any given tasks. Job incumbents (the SME raters) simply have different experience which can limit their knowledge of tasks and associated WUCs. Interrater agreement based on individual SME ratings should be expected to be low. As far as reliability of the verification and mapping process, the better approach would appear to be use of two or more groups of 2 - 4 SMEs as the basis for computing agreement among groups rather than among raters. Further justification for the use of two or more groups of raters are the differences among units in the assignment of maintenance. Job incumbents at one base may not work on exactly the same set of WUCs as do the incumbents at another base.

4. Primary Problems. There were two primary problems observed during the SME verification and mapping sessions. First, as already suggested, was the problem of communication--the difficulty that an SME has in understanding the meaning of tasks. There, obviously, is no solution to this problem for historical data, except to permit the SMEs to cooperate by pooling their experience to arrive at a consensus meaning. For future surveys, use of MDCS data should improve communication with SMEs (and respondents) by providing more precise (v. more generic) equipment identification, especially if weapon system-specific task lists are employed. Even these kinds of tasks, however, cannot be expected to eliminate the communication problem associated with the variance of experience of the SMEs. Pooling of SME experience seems to be the best solution for improving SME understanding of task statements.

The second problem is the large number of tasks provided for SME review that have no possibility of being matched with WUC information (52 percent for AFS 422X1B and 46 percent for AFS 454X3). There are two possible solutions, each having to do with the data screens employed before the SME booklet is produced. The first solution lies in improvement of the WUC-AFS crosswalk screen. As will be discussed later, use of base level CAMS data tapes offer the most attractive solution.

The solution to the second problem involves reduction of the number of tasks presented to the SMEs for which WUC information can be mapped. This problem is largely a function of the screen applied to the OSM data for purposes of generating the job description to be used as the basis of the matching. To provide the broadest mapping source, the present effort selected tasks performed by 15 percent or more of the 5-skill level workers who indicated they worked only on the F-15. In future efforts, this screen can be adjusted

to raise the percentage performing requirement and include additional screens based on task difficulty or training emphasis. Reduction of the number of tasks should not be significant from training and classification perspectives, because the use of tasks performed by small percentages of workers, or tasks with the least difficulty, serve little purpose. Effects of changes in the screens on the number and kinds of tasks to which SMEs respond should be explored.

5. Accuracy of WUC-AFS crosswalk screening. As indicated above, the quality of the WUC-AFS crosswalk was an inadequate basis for the WUC screen for AFS 422X1B. A more accurate crosswalk screen is essential, both for the efficiency of semantic mapping and for task development. If anything, the crosswalk accuracy is more crucial for developing weapon system-specific task lists. Any WUC omitted during application of the SAAT on historical data can be recovered from the SMEs review. **For inventory development, any missing WUC equates to one or more missing tasks.**

6. SME verification. Observation of the SMEs during the verification sessions as well as critical review of the final mapped product revealed minor formatting and algorithm problems. The formatting problem involves the use of the entire task statement as the basis for SME verification and mapping. The OSM task verb (the action taken) was a source of confusion. On several occasions, SMEs indicated that they performed maintenance on the WUC mapped to a task, but that they did not perform the action taken specified by the OSM task verb. For example, AFS 452X1B personnel indicated they performed maintenance on angle-of-attack transmitters, but that they did not boresight them, as the OSM task stated. A modification that should eliminate this problem will be described under the section detailing enhancements.

Review of some WUC-task mapping results suggested that the algorithms for mapping a WUC to task may be too severe or restrictive. There were instances in which WUCs were appropriately mapped to one task but not mapped to another task having the same WUC equipment item. To preclude these occurrences, the algorithmic parameters for mapping WUCs to task statements needs some minor adjustment.

Enhancements of the SAAT

Several enhancements of the present SAAT offer the potential for improving the quality of the OSM-WUC data match provided to SMEs for verification and editing. SME workload can be minimized by reducing the tasks they review to those that are performed in their AFS and for which there is a high probability of the correctness of the WUC matching. Enhancements also will reduce the work associated with preparing OSR and WUC

information for SAAT processing. The first three needed enhancements, described in the following paragraphs, involve modification of existing software.

1. A modification of the SAAT, that can be very important for improving the accuracy of the mapping, involves use of the MDCS maintenance data files as the data base for SAAT mapping. There are two improvements that may result from use of the maintenance data base: (a) informational value of tokens used for mapping can be sharpened; and (b) the array of WUCs used in mapping will be limited, thus reducing the number of extraneous WUCs appearing in the SME booklet.

First, present SAAT matching is based on the "information value" of tokens (words, phrases, concepts) that, simply stated, is calculated from the frequency of occurrence of the tokens' occurrence within their data set as compared to probability of occurrence outside the data set. A given token in the WUC data set, for example, has a value based on its frequency of occurrence <u>within that set</u>. The same is true for any token in the OSM data set.

There are data, however, contained in the MDCS and OSM data bases, associated with the tokens and which have merit for enhancing the "information value" of the tokens with which the data are associated. For the MDCS, the frequency of occurrence of maintenance actions on a particular WUC token can be used in computing the information value of the token. Percent performing and percent time spent data are key data elements for weighting the information value of OSM tokens. Obviously, within the data set and outside the data set probability of occurrence values would be affected by use of the additional data. The result of these effects would be an improvement of the overall mapping.

This modification of the SAAT involves changes in both the mapping algorithms and microcomputer programs to permit accessing the WUCs and OSM task data essential for computing the weighting values. The modification also involves changing the WUC data set that is presently a basis of the mapping process. This change involves another needed enhancement discussed in the following paragraph.

Use of the MDCS maintenance data files would also provide a source for two further screens (in addition to the WUC-AFS screen), applied to WUCs <u>before</u> mapping, by limiting the data base used for SAAT mapping to only those WUCs that are reported. First, as the SAAT was originally designed, the B-4 Master File is the WUC data set used for mapping to OSM tasks. The B-4 Master file contains <u>all</u> of the work unit codes pertaining to a given aircraft, communication-electronics system, aircraft support equipment (such as Aerospace Ground Equipment), or missile. When the fifth character level of WUC is included, a very specific level of definition exists, and the number of codes normally runs into the thousands. As a result there is a high probability of matching a token from an inappropriate WUC to an OSM task. Further, at least in many AFSs, job incumbents do not perform maintenance

at this level. The SAAT mapping is therefore not as accurate and representative of an AFS as it could be.

By changing the data set from the B-4 Master File to that obtained from the maintenance data tape for the aircraft or other interest item, only the work unit codes that personnel report for work on the aircraft of interest will comprise the data set used for mapping. This data set will represent the complete set of WUCs. Extraneous WUCs, either because the WUCs are inappropriate to the AFS of interest or at a too specific WUC level, would not be available for inappropriate mapping.

Second, these WUCs could be further screened, since it is possible that some WUCs that have low frequencies of repair should be screened before mapping, especially if task list length is at issue. These are the WUCs for which there is the greatest probability that the Job Inventory for the AFSs will not have an appropriate task or very few job incumbents report that they perform.

2. A second modification involves the use of a more strict screen in conjunction with one or more add-back features applied to OSM tasks. This modification would result in a reduced SME workload by providing tasks that are most likely to be performed by the AFS on the weapon system, or other equipment, of interest. As the SAAT has been applied to date, OSM tasks have had two screens applied. In previous testing, the screens limit the tasks to those performed by 15 percent or more job incumbents who work only of the F-15. As the results of the verification and editing of mapped data by SMEs with AFS 452X1B and 454X3 indicated, a large percentage of tasks (26 and 29 percent, respectively) were not, according to the SMEs, tasks that incumbents of the AFS should perform, or were not tasks that could be performed on the F-15. Review of the tasks indicates that most of them are performed by small percentages of personnel.

Investigation of changes in the screens as well as the use of add-back options is needed to eliminate, or at least reduce, the number of spurious tasks. One possible change involves setting the minimum percent performing screen at the mean (or some such standard) percentage of incumbents performing tasks. Potential add-back options include use of task difficulty and training emphasis ratings. These ratings could be applied to add any task for which probable relevance to the AFS is high, such as one standard deviation above mean difficulty rating and above mean training emphasis rating. Use of the difficulty criterion would ensure that relevant tasks performed by percentages not meeting the minimum percentage cutoff (as is frequently the case for difficult tasks) would be included in the mapping. Training emphasis ratings in a sense are an indication of the relevance of a task to the work of a specialty. Thus, any task exceeding the mean value probably should be added even though it did not meet the minimum percentage performing cutoff.

3. Another modification involves the formatting of the SME booklet. As discussed in preceding paragraphs, SMEs identified tasks containing WUCs that they reported but not for the action taken represented by the OSM task statement. Hindsight suggests that the SME booklet should not include the entire task statement, because some of the SMEs' confusion during the verification and editing process centered on the question of their performance of the action taken implied by the OSM verb. The SAAT OSM task-WUC mapping, that the SME uses for verification and editing, is based on the use of the task-verb objects, essentially the noun phrases, in the OSM task statements. It is not until after SME verification that task verbs and actions taken are mapped. Mapping against the objects would not detract from the quality of the final data, because the maintenance data from the MDCS data files, showing the action taken on the WUCs, will indicate whether job incumbents perform the action taken implied by the OSM task verb. Present SAAT software should be modified to change the SME booklet format to one in which WUCs are mapped to the task verb objects or noun phrases.

4. The fourth modification involves the testing of various parameters, such as the within-set and outside-set values, for matching WUCs to OSM tasks. Minor software revision would be required to permit variation of the levels of the parameters. At least some of the testing and validation of the within- and outside-set parameters could be accomplished on OSM-MDCS mapping data obtained from previous tryouts.

The remaining enhancements are needed to improve the quality of the final mapped product, and minimize the time and work of SAAT preprocessing and SME verification and editing. They relate to the acquisition of better sources of WUC-AFS crosswalk information and an automated source of fully-expanded WUC titles. These enhancements are described below.

1. A better source of WUC-AFS crosswalk data is critically needed, since the LCOM Percent Contribution Reports used in previous SAAT research, although readily accessible, are inadequate. So far, three approaches to obtaining WUC-AFS crosswalk information have been used. First, through personal interviews, SMEs used a WUC manual to check the WUCs they reported when they performed maintenance. This approach was highly effective, but more resource intensive than is desirable (except as a last resort). Second, the LCOM Percent Contribution Report has been employed, and the results of the F-15 mapping research indicates it is inadequate for mapping. For use in developing weapon system-specific tasks, it is totally inadequate, because the WUCs employed in LCOM work are usually truncated to the 3-digit level.

Third, a mail survey has been employed. Technicians with AFS 452X3A,B,C were mailed a booklet in which possible WUCs which they would report when working on the B-1B were included. The WUCs provided in the booklet were extracted from the preliminary WUC for the B-1B. The technicians were asked to check the WUCs they reported and write-in any WUCs that had changed or was not included in the list provided. Nine of ten SMEs (one SME had been reassigned) complied with the request. Numerous WUCs were written-in. Most write-ins were the result of amendments to the manual from which the WUC extracts used in the booklet provided to the SMEs were made. The primary problem noted was that some of the SMEs did not provide the WUCs in the amendments but, instead, only referred to the amendment number for the WUCs. Fortunately, for this effort, other SMEs provided the specific WUCs included in the amendments which were not available to the project team. Any future use of a survey methodology should incorporate explicit instructions to transcribe all WUCs rather than refer to manual amendments. The quality of the survey responses were not verified, since the data were used for producing a B-1B-specific task list, not for mapping (in the mapping process, SMEs would be verifying accuracy of WUCs along with mapping the codes to OSM task statements). Thus, there was no opportunity to obtain further SME verification. It is clear, however, that in some cases the SMEs, checked different WUCs. This fact is not unexpected. Not all incumbents of an AFS perform the same work; any given SME may not be familiar with all of the WUCs for the AFS.

While there are the three other potential sources of WUC-AFS crosswalk information just described, the best source can be found in base level CAMS data tapes. As indicated in AIR FORCE CROSSWALK (1989), in the approximately 60 percent of units employing CAMS, WUC-AFS data are stored on base-level data tapes for a period of up to six months. Procedures should be established for obtaining an extract of these tapes showing the WUC-AFS crosswalk from at least two bases maintaining the aircraft for which mapping is desired. Minor software development would be required for preprocessing the data for SAAT processing.

Since WUC-AFS crosswalk information is **crucial for** future SAAT applications or **inventory development efforts**, access to CAMS base level data tapes is very important.

2. By far the most time consuming and confusing preprocessing is the expansion of the abbreviated WUC titles, which are the basis of the mapping process. It is one of the most crucial steps required for applying the SAAT. The B-4 Master File allocates only 19 characters for the WUC title. Therefore, abbreviations must be used which are not only short but are inconsistent from one usage to another. Each abbreviation must be expanded to the full word for which it stands. To date, no source, automated or otherwise, has been available for the process.

At this time, the more promising of two potential solutions is the creation of a kind of thesaurus or look-up table based on the expansions of the WUC titles for the F-15 and F-16 already accomplished. In accomplishing these expansions, a very large number of duplications of WUC abbreviations between the two aircraft were observed. Similar duplications for other aircraft can be anticipated--most aircraft, for example, will have fuel quantity indicators, speed indicators, altimeters, transmitters, and so on. While there are variations of the abbreviations that may be used for these items, once the abbreviations are identified and expanded, they readily translate to other WUC titles for other aircraft or systems.

It is likely that a look-up table containing most of the abbreviations and their expanded forms can be constructed from the F-15 and F-16 expansions. Arrangement of the WUC in the look-up table should be based on some structure like that to be found in DoD Standard 863B or in MIL-M-38769C (USAF). This structure would assist in identifying the preferred expansion of an abbreviation for which there are two or more options. Subsequently, the look-up table would be amended as new abbreviations were encountered. This look-up table could be incorporated in the SAAT software so that, during expansion of WUC titles, the first step would be a look-up of an abbreviation when it occurs.

Very late in the course of this project, information was received from the Air Force logistics community that a source may exist in which the fully-expanded titles are available in electronic format and on microfiche. According to the information, part number, WUC, and the full titles are available in the Mission Incapable Report (MICAP). This source should be investigated further.

The SAAT is friendly software, but it is not menu driven in the sense that all explanatory information is not displayed on the screen. The documentation, however, is very explanatory. Any computer technician familiar with microcomputers and with CODAP setup and use of the AFHRL UNISYS 1100/82 can use the SAAT.

V. FACTORS BEARING ON THE DEVELOPMENT OF WEAPONS SYSTEM-SPECIFIC TASKS

The basis for developing weapon systems-specific tasks to be used in the OSM survey methodology, rests in the use of microcomputer methods for extracting records of the actual maintenance performed on aircraft during a given period of time from MDCS files. Job Inventory tasks, used in future OSM surveys based on these maintenance records, or at least precoding of OSM tasks with MDCS work unit and action taken codes, can provide highly specific aircraft data. They also offer the potential for reducing or eliminating the need for

Semantic-assisted Analysis Technology mapping of OSM and MDCS historical task level data. Development of such methods not only can provide the specific level of information needed for certain manpower, personnel, and training purposes, but they offer the potential for improving the coverage and quality of OSM maintenance task lists.

This section will address the use of maintenance data to develop specific tasks from several perspectives which follow the requirements for developing tasks that elicit reliable job incumbent data, the basis of current OSM inventory development and data collection practices, the levels of task description that facilitate the various uses of OSM data, and the scope of the need to develop weapon system-specific task lists.

Task Characteristics

There are five characteristics that drive the development of tasks included in a OSM Job Inventory (Morsh & Archer, 1967; Driskill et al., 1987). First, tasks should be expressed in language that communicates clearly to the respondents; second, tasks should be mutually exclusive or independent of one another; third, tasks should be expressed at about the same level of specificity; fourth, they should differentiate among workers; and fifth, they should be time ratable. The first four characteristics have implications for the approach used in building specific task inventories from maintenance data.

Communication

MDCS data to develop OSM tasks can be most useful in preparing tasks that communicate clearly with respondents. In the mapping of F-16 and F-15 data, there were instances noted where the generic nature of the tasks led to misunderstanding (Driskill et al., 1987). For mapping purposes, the OSM job description employed was for 5-skill level personnel working only on the F-16. Nevertheless according to F-16 subject matter experts reviewing the OSM-MDCS mapping, more that 20 percent of these personnel indicated they performed tasks on systems that are not on any model of F-16. Wagner (1986) also noted the same problem. The testing of SAAT on F-15 data in this study also revealed this problem. MDCS data can lead to a more comprehensible expression of systems, subsystem, and components.

Independence

In terms of the independence of tasks, use of MDCS data in developing task statements has two sides. The lack of independence of tasks noted in present OSM practice (see Wagner, 1986, for example) can be avoided if MDCS data is used in task development.

Task statements appearing in inventories generally reflect work at the third character (system) of the MDCS data; however, most inventories contain some task items that describe work at the fourth and, sometimes, the fifth character of the same systems. Redundancy occurs when tasks relating to the same item of equipment are developed at two or more of these levels. Use of the MDCS during OSM task development should preclude this kind of redundancy and enhance task independence.

The other side of using MDCS data, however, is that the same or highly similar WUC equipment descriptors may be used for several different aircraft. For example, the Job Inventory for AFS 423X3 has this task: Remove or install hydraulic radiators or fuel oil heat exchangers. This task is generically stated and is intended to represent work performed on fuel systems of numerous aircraft. On at least two of these aircraft, the F-16 and the F-15, the WUC descriptor is the same: Fuel oil heat exchanger (WUC 46ADE for the F-15 and WUC 46APO for the F-16). If these descriptors were used separately (as in separate task lists for each aircraft) to describe work performed on the two aircraft, each task statement must be modified by the aircraft designator (e.g. F-15 fuel oil heat exchanger). Otherwise, in a consolidated job description across aircraft for the AFS, both tasks would appear to be identical, when in fact they are different for the F-15 and F-16. Development of weapon system-specific tasks must take into account WUC descriptor similarities if the data are to be accurately aggregated across aircraft systems for different aircraft types.

Specificity

Since tasks in inventories describe work at different WUC levels, task specificity varies. Sometimes, work performed on one system is described at the system or subsystem level (third and fourth character). Other times, work performed on a system will be described at the component level (fifth character). Differences of specificity impact the computation of percentage of time spent on task performance. More percent time spent will be computed for systems that are more specifically described. Use of MDCS data to develop task lists can reduce differences of specificity by standardizing the WUC level at which task lists are developed.

Differentiation

It is important to have differentiation among workers (for example, identify differences in the tasks performed by experienced and inexperienced job incumbents). The MDCS data are based on a fixed set of action taken codes. That may be inadequate for providing the discrimination among worker experience required for OSM tasks. OSM task development does not use a fixed set of verbs (or actions taken). Instead, the verbs, elicited from subject matter experts, are used to provide for differentiation among workers in the AFS.

In the SAAT mapping of OSM to MDCS tasks, OSM task verbs were converted, with the cooperation of USAFOMC inventory development personnel to MDCS action taken codes (Driskill et al., 1987) prior to SAAT mapping for purposes of matching. The reverse, working from MDCS tasks to OSM tasks, can be followed for developing task statements. To provide for more accurate OSM task description during inventory development, a glossary of verbs should be compiled. Such a tool would show the relationship of OSM verbs to corresponding MDCS action taken codes with guidelines prescribing the differentiating qualities and how they should be applied. In addition, specification of the method of matching task verbs to actions taken codes will be required.

In addition to these task characteristics, there is an implicit requirement that the tasks extensively cover the work of chosen occupations being described. While it is unquestionably true that any task list is only a sample of the work performed, that sample of tasks should represent a comprehensive description of the various types of work in the various jobs making up an occupation. MDCS data should provide this comprehensive coverage. As pointed out in an earlier report (Driskill et al., 1987), various sources have questioned the reliability of these data. For purposes of developing task lists, however, reliability of workload data is not an issue. The goal is to generate a listing of the tasks performed in the maintenance of a given aircraft or piece of equipment. The MDCS data base of maintenance performed across the force-wide inventory of a specific aircraft or piece of equipment, should provide comprehensive coverage of all WUC equipment items and actions taken on these items.

Current Inventory Development and Data Collection Policies

Implications of the change in the nature of tasks used to collect occupational survey data are discussed in this section. Two perspectives are reviewed. First, current inventory development practices are described, and the rationale for these practices are given. Second, implications of changes in the character of Job Inventories on present data collection and analysis procedures are enumerated. Information for these discussions were obtained from two sources: a large number of Job Inventories used in OSM surveys of maintenance specialties during the past 9 years, and interviews of USAFOMC personnel.

Inventory Development Practices

Review of the job inventories led to four conclusions:

- o Job Inventories include all of the tasks describing the work comprising a specialty or specialties being surveyed.

- o Each Job Inventory includes general and generic tasks such as those pertaining to management, supervision, and training.

- o As the number of weapon systems covered by an AFS increases, the generality and number of generic tasks increases due to the desire to reduce task list length.

- o OSM task statements consistently begin with verbs or verb phrases, but the semantics of the verbs or verb phrases are inconsistent.

The following paragraphs provide further explanation of each of these conclusions.

In regard to Job Inventory coverage, except in very rare cases, tasks describing work performed by personnel with specialty shreds are included. Also, several specialties and their associated shreds may be combined in a single inventory. This practice is dictated by the need for determining the similarity of task performance among the shreds or specialties. In defining similarity of task performance, survey respondents must have the same frame of task reference for their time spent, task difficulty, training emphasis, or other factor ratings. **If the task data are not collected in a single inventory some method for benchmarking tasks among inventories is required to equate ratings across tasks.**

Second, each Job Inventory, describing either single or multiple systems, includes <u>general</u> and <u>generic</u> tasks (excluding tasks comprising Job Inventory Duties A, B, C, and D, such as those pertaining to management, supervision, and training). These tasks describe work job incumbents perform in their specialty or specialties. Each of these two categories consist of two classes of tasks; they are differentiated because they serve different purposes in inventories.

<u>Aircraft-equipment general</u> tasks are used to describe work performed across all aircraft and associated systems by job incumbents without regard to AFS or equipment items whose WUCs are not included under the aircraft WUCs. The WUCs for the latter class of items are provided in separate publications and their maintenance is usually the responsibility of other specialties. Examples of some aircraft-equipment general tasks are as follows: <u>Jack aircraft, Fuel and defuel aircraft, Calibrate simulators or mockups, Clean test station filters, Position maintenance stands, and Position powered or nonpowered AGE to aircraft</u>.

Under the MDCS, work supporting a specific aircraft not related to specific aircraft system maintenance, or which is related to general kinds of maintenance (i.e., corrosion control) is normally recorded under Support General or Inspection WUCs. General task statements usually are employed to describe work performed under these codes as well as to describe work on equipment for which the specialty does not have primary responsibility. For equipment which is not a part of a basic aircraft system, work performed by incumbents of a specialty with primary maintenance responsibility on that equipment is recorded using

Work Unit Code manuals for the specific equipment. The WUCs and ATCs in these manuals can be used to develop tasks for the specific equipment. Use of the Support General and Inspection Codes (recording production credit of repetitive tasks of a general nature) to develop general tasks applicable across aircraft and specialties should be explored, since there is a high degree of similarity among these codes and task statements across aircraft. These codes appear in each WUC manual and are standard across manuals.

AFS general tasks are used to describe work that cannot be directly related to a WUC descriptor and, in most cases, is performed almost exclusively by members of a specific AFS. These tasks describe work required to **support** the maintenance of specific aircraft systems, listed in WUC manuals. Normally, work involving these support maintenance tasks is recorded in the MDCS under Support General Codes. They are necessary to account for the full range of specialty incumbents' performance. The following examples were extracted from the Fuels Specialty to illustrate AFS general tasks: Direct hydrazine spill clean-up procedures; Notify fire department of fuel systems maintenance, and Position drip pans. SME input for the development of Support General tasks is necessary.

Two classes of generic tasks are WUC nomenclature-generic tasks, and methods, procedures, or materials generic tasks. WUC nomenclature-generic tasks are used to describe aircraft system maintenance or off-aircraft equipment maintenance tasks when there are similarities of the tasks across multiple aircraft, or similarities of off-aircraft equipment items, maintained by a single specialty. The WUC nomenclature from which the generic tasks are generated can be found in the individual aircraft or equipment WUC manuals. Under present technology, use of generic tasks cannot be avoided. They are utilized to describe systems that are similar in varying degrees across several aircraft or aircraft systems (e.g., engine supply systems, fuels, instruments, flight controls). A task list, for a specialty covering multiple aircraft or equipment items, could quickly become too long for mail survey administration under existing procedures, if separate tasks were written for each piece of equipment on each aircraft.

The second class of materials generic tasks describe methods, procedures, or materials that may be used to repair or maintain systems, subsystems, or components maintained by a specialty. Typically, since the tasks can be performed on a variety of systems, no reference is made to any WUC nomenclature. Work described by these tasks is peculiar to a given specialty and may be accounted for under MDCS ATCs and WUCs. Typical tasks of this type are found in specialties like AFS 427X5, Airframe Repair Specialist, and AFS 427X1, Corrosion Control Specialist.

The third conclusion is that not only do ways used to describe tasks vary, but as the number of weapon systems covered by an AFS increases, the number and generality of the descriptors for the generic tasks increase as well. Primarily these increases result because of the need to reduce task list length. In single aircraft AFS like those for the F-111, F-15,

F-16, and the B-1B, task list length is not at issue, and many of the tasks referring to specific WUC equipment nomenclature are written at the fourth character (subsystem) level of the WUC. Production of these tasks from MDCS data, using microcomputer methodology already developed, can be accomplished. Further, even if the microcomputer methods for deriving task statements from MDCS data are not used, after-the-fact SAAT mapping is straight forward because the descriptive terms used in OSM tasks are generally similar to MDCS equipment nomenclature.

In inventories covering a few aircraft or equipment items or an AFS that has major command shreds, as in AFS 455X2, Communication and Navigation Systems Specialist, tasks are reasonably identifiable with WUC nomenclature. Although generic, they are usually written at the third and fourth (subsystem and sub-subsystem) levels of the WUC. For example, here are two such tasks: Isolate malfunctions to compass amplifiers, and Remove or replace reconnaissance adapter units. For such specialties, the length of the task list is unlikely to become too long. SAAT mapping is more effective for these AFS than for those AFSs which cover maintenance of all aircraft.

Tasks for specialties covering all or many aircraft or equipment take on two different generic forms. For six specialties like AFS 427X5, Airframe Repair Specialist, and AFS 427X1, Corrosion Control Specialist, aircraft system references are not used. Methods, procedures, or materials generic tasks are primarily utilized, such as these two examples from the Job Inventory for AFS 427X5: Perform solid laminate repairs, and Cut replacement honeycomb core using cylindrical core cutter. It is questionable whether weapon system-specific tasks should be developed for the few specialties like these. Also, as the tasks are presently described, semantic-assisted analysis techniques cannot be applied.

In specialties like Airframe Repair and Corrosion Control, the methods, procedures, or materials generic tasks are more efficient and descriptively more parsimonious. From personnel classification, promotion testing, and training perspectives, the kinds of airframe parts upon which the specialist works are not nearly so important as what is done to repair or maintain the material from which the parts are made. If tasks were written around WUC identification, either the type of material from which airframe parts are made would have to be derived from analysis subsequent to the survey; or a separate task for each part made of a different material with an indication of the type of material would have to be written. It would appear to be very difficult if not impossible to develop generic task statement based upon equipment nomenclature and provide information about materials.

In a larger number of specialties like AFS 454X3, Fuels System Mechanic, tasks that generally target aircraft system and components are included as well as tasks that are similar in character to those in the Airframe specialty, such as these: Perform red talcum powder tests; Apply protective topcoat sealants. Design of an intelligent system for developing these kinds of tasks is made very difficult. Furthermore, semantic-assisted analysis techniques will not map these tasks with WUC data. The mixing of the generic tasks describing work

processes, and those targeted at WUC nomenclature tasks in a single inventory also provide the setting for overlapping or redundant tasks.

When these broad specialties contain WUC nomenclature-generic tasks (that is, tasks that target similar systems across aircraft), task content may represent WUCs third, fourth, fifth character (sub-subsystem), or a combination of these levels. No evidence has been identified that suggests a systematic approach to identify the levels to be used. Examples of WUC nomenclature-generic tasks from the Job Inventory for AFS 454X3 are: <u>Isolate malfunctions of air refueling systems of receiver aircraft; Remove or install air refueling receptacles</u>.

The last two examples, although they refer to descriptors used in WUC manuals, are in a sense "aggregated" tasks; they are intended to describe the work performed on any aircraft having air refueling receiver systems. Generally, they are written at the third character (subsystem) level of the WUC for aircraft. In the example tasks above, selection of a generic descriptor was suggested by the commonality of equipment nomenclature for air refueling systems across aircraft. Sometimes, however, a generic descriptor must be created to classify the aggregation of equipment to be described, because of equipment nomenclature variations across aircraft WUCs.

To further illustrate this point, the Fuels Specialty has numerous valves with WUCs for various aircraft. Although frequently WUC descriptors will not be included to indicate whether a valve is a "check" valve or a "float" valve, task statements will be written like these: **<u>Remove or replace check valves</u>**, and **<u>Remove or replace float valves</u>**. The assumption is made that all job incumbents will know which valves are check valves and which are float valves when they respond to the task statements. Additionally, it may not make any difference in the quality of the data collected to know which respondents work with check as opposed to float valves; it may be sufficient to know that they remove and replace valves.

Equipment-related tasks can be mapped semantically, although the quality of the mapping is a function of the specificity of the generic descriptors used. The choice of descriptors not only affects the ability of subject matter experts to map WUCs to task statements that incumbents indicate they perform, but can affect how accurately job incumbents respond to the tasks. Tasks presenting the greatest mapping and communication problems are those for which the differences of nomenclature across aircraft is such that a generic descriptor is not easily generated from the WUC nomenclatures. Development of a technology of generating tasks from MDCS information which incorporates intelligent or computer-assisted methods should be possible and should improve both present semantic mapping capability and the specificity of weapon system task information.

The last conclusion is that OSM tasks are both consistent and inconsistent in the way they are expressed. They are consistent in that task statements begin with verbs, or a verb phrase (the action taken), followed by the object--the thing acted upon. They are inconsistent in the way verb phrases are written. Sometimes the initial word of a task statement is a verb modifier, as in "Operationally check." Verb phrases are employed in different forms, as in "Isolate malfunctions in air refueling systems," and "Isolate electrical malfunctions in electrical circuitry." While there is no communication problem, the different usages present problems in designing an intelligent system and in semantic mapping.

Data Collection and Analysis Policies

In terms of survey policies and practices, occupational survey Job Inventories contain **all** of the tasks job incumbents in the specialty (or specialties) and the shred being surveyed may perform. There are five primary reasons supporting this practice:

- o All job incumbents have the same frame of task reference when responding to survey instruments.
- o Job incumbents of maintenance specialties frequently perform maintenance tasks on more than one aircraft.
- o Use of a single inventory facilitates hierarchical grouping analysis.
- o Input programs for ASCII CODAP cannot easily aggregate and analyze multiple inventory data.
- o Fewer resources are required for preparation, administration, and data analysis of a single inventory.

The following paragraphs provide further explanation of each of these reasons.

First, all job incumbents have the same frame of task reference when they respond to the same set of tasks in making their relative time spent, task difficulty, training emphasis, or other task factor ratings. Having the same frame of reference, especially when rating task difficulty and training emphasis, is extremely important because of the use of relative rating scales. If inventories are administered such that job incumbents do not have the opportunity to respond to all the tasks describing the work of a specialty (that is, different subsets of tasks for different subsets of respondents), the task factor values would apply **only** to the tasks that a particular subset of respondents rated. These factor ratings could not be applied across a specialty without the use of techniques for equating ratings across the complete set of tasks comprising the work of an AFS. The equating problem, however, is

not insurmountable; some set of "common" tasks could be used across separate subsets and serve as "benchmark" tasks for equating purposes.

Two kinds of tasks offer possibilities to minimize the benchmarking issue. First, as indicated in a preceding discussion, every Job Inventory contains both general and generic tasks which are necessary to describe the work of a specialty but which are not WUC nomenclature-specific. Opportunity for response to these tasks can be provided to each respondent and task factor rater in a survey. These tasks could be benchmark tasks. Second, generic tasks that are WUC nomenclature-specific, if they can be successfully generated, would provide a better source of equating task factor ratings as well as better serve some of the applications of OSM data.

In either case, success depends upon the existence of a standard taxonomy of basic aircraft systems and subsystems, development and consistent application of a "standard" set of generic tasks, and, if necessary, development of a semantic-assisted approach to consolidating similar nomenclature from different aircraft. A standardized taxonomy is requisite for organization of tasks across aircraft covered by an AFS. The "standard" generic tasks can be generated from the Support General and Inspection Codes, which are highly similar across aircraft. The SAAT has the potential for aggregating nomenclature for similarly-named equipment across aircraft for use in generating a meaningful generic descriptor.

Second, job incumbents of maintenance specialties frequently perform maintenance tasks on more than one aircraft. If tasks describing all aircraft are in the same inventory, collection of data from incumbents working on multiple aircraft is facilitated. Because of the difficulty in determining which combination of aircraft any given incumbent maintains **before** Job Inventories are mailed for data collection, utilization of separate task lists for each aircraft can inhibit data collection. Changes in present procedures for determining where Job Inventories should be mailed for data collection could possibly provide for incumbent responses on multiple aircraft upon which they work. These changes would involve either use of the Program Element Codes against which job incumbents are assigned, or a pre-survey to determine data collection locations and incumbent requirements prior to mailing Job Inventories. Computer administration, especially a computer-adaptive system, would largely negate the data collection issue. The major concern would then be length of the Job Inventory, since ASCII CODAP will not accept more than 3,000 items; however, a truly adaptive system would not face the length problem.

Third, use of a single inventory consisting of generic tasks facilitates hierarchical grouping analysis to identify the different generic jobs in specialties crossing multiple aircraft. Job groups specific to a given aircraft seldom can be readily identified. Separate inventories, or inventories consisting of specific tasks by aircraft, would guarantee job types peculiar to each aircraft. Different incumbents would respond to different subsets of tasks. There is considerable merit to these latter kinds of job types, especially for use in

determining personnel requirements during the system acquisition process, because of the specificity of job definition. The disadvantage is associated with the inability to identify similarity of the work performed across the job groups that is important for certain other manpower, personnel, and training uses. Some type of benchmarking tasks, however, could reduce or eliminate the problem of hierarchical grouping of incumbent data collected from separate inventories.

Fourth, the input programs to ASCII Comprehensive Occupational Data Analysis Programs (ASCII CODAP) for both Sperry and IBM mainframe computer analysis are not designed so that data from separate inventories can be easily aggregated and analyzed. In addition, no more than 3,000 tasks and background information items can be analyzed by ASCII CODAP. If tasks are developed for all aircraft, whether they are administered in a single inventory (by mail or computer) or in separate inventories, the number of tasks in inventories for some specialties can be expected to exceed the maximum that can be analyzed. Thus, it will be imperative that the method or methods for generating a single task inventory accommodate AFS for which a multi-aircraft Job Inventory will be too long for processing.

Finally, fewer resources are required for the administrative preparation, mail administration, and data reduction of a single inventory. Involved are costs of manuscript preparation and quality control; Job Inventory printing, mailing, tracking and accounting, and quality control of responses; and optically scanning incumbent responses. These costs would simply be multiplied by the number of separate inventories used. Computer administration could be expected to reduce some of the additional costs of "separate" inventories.

In terms of data analysis, the reporting of job data for considering classification structuring issues and supporting training decisions are primary objectives of the OSM. Data are required which indicate the degree to which job incumbents of a specialty or specialties, if they are surveyed in a single inventory, perform the same tasks. This information is one piece of information essential to restructuring considerations. Important analysis tools are composite job descriptions for various categories of the respondent population, hierarchical grouping analysis to identify job groups and the characteristics (such as AFS or experience level) of the job incumbents comprising each group, and comparisons of task factor data. Use of multiple inventories complicates these kinds of analyses, for reasons already cited.

Implications of Weapon System-Specific Tasks for Data Users

In the over 20 years that the Air Force Occupational Analysis Program has been operational, survey data have been utilized in numerous research projects and for a wide variety of personnel and training purposes. As a result, the OSM approach aims at collecting data that can be analyzed for as many purposes as possible.

Although the potential for using these task and job data in acquisition planning was recognized almost at the inception of the Program, it was not exploited. Only recently has any real thrust to capitalize on the data been initiated. It is this thrust that produced this research effort to map OSM and MDCS data and to build more weapon system-specific task lists. This effort if the methodologies produced by it are successful, could not only cause important changes in the way the USAFOMC presently develops, administers, and analyzes occupational surveys, but could produce significant changes in the characteristics of the data collected and reported.

For these reasons, careful consideration must be given to the implications of changes in the nature of the data for various survey data applications in the design of new approaches to task development and administration. To illustrate the implications, this section will briefly examine the kinds of tasks most useful for three of the major applications of occupational data: structuring specialties, training, and development of test outlines for Specialty Knowledge Tests. These three uses adequately show how the kinds of tasks presently employed in the OSM are useful in some applications and, as well, how specific tasks would facilitate their use in other applications.

Structuring Specialties

Historically, broad, generic tasks satisfied the requirements for structuring maintenance specialties, but in recent years the basis of classification is changing. Review of the current Airman Classification Chart and specialty descriptions in AFR 39-1 shows that there is a mixture of the ways maintenance specialties are organized. In some specialties as they are presently structured, generic tasks appear suitable -- for example, the Fuels and the Egress Systems specialties. In these cases, simple functional commonality of the equipment maintained, and thus similarity of system knowledge and skills which are driven by the functional similarity, are the bases for classification. Generic task statements, as used in current OSM, satisfactorily answer classification questions, since commonality of task performance is the basic issue.

There are other specialties, however, in which classification is based on other considerations. Management of people, proximity of systems or work location, and overall weapon system or work environmental orientation (as opposed to similarity of system knowledge and skills) seem to be more important classification factors than functional similarity of systems or specific functional knowledge and skills requisite for work on specific systems. Knowledge and skills requirements are considered from a broad base, such as commonality arising because different systems all reside on the same aircraft. An example of a specialty based on aircraft identification or orientation is AFS 455X2, F-16 Avionics System Specialist, that includes shreds through the 5-skill level for work on Attack Control Systems; Instruments and Flight Control Systems; and Communication, Navigation, and Penetration Aids Systems. The commonality of fundamental knowledge among these

shreds is most apparent in proximity, aircraft, and basic electronics theory. This specialty is a composite of parts of three other previously-existing specialties based on commonality of systems functions rather than aircraft commonality. Although the new specialty structure is based on aircraft identification, the integrity of the functional similarity of the three previous specialties has been perpetuated by the three shreds. Since the new AFS provides for specific-aircraft orientation, the only kind of task statement of value for this and similar AFS are very specific to the systems on the designated aircraft.

Similarly, if in the future other generic specialties are to be decomposed into separate specialties, weapon system-specific tasks and associated data can be useful. The task verbs used to describe maintenance actions (i.e., troubleshoot, align, adjust, install, remove, replace, operationally check, test) classify the kinds of maintenance action, and associated aircraft systems knowledge, and hands-on maintenance skills as a part of the basis for structuring. Another prerequisite of the structuring basis which still must be determined is identification of the degree of similarity of the knowledge and skills required by the specific (as opposed to the generic) equipment items (the task statement verb objects) to perform the maintenance actions (the task statement verbs) required. Almost certainly, more precise judgments of similarity can be made about the specific objects than would be possible from general judgments made across the objects. It is, of course, these specific knowledges and skills that constitute the greatest training load.

As a general rule, it is easier to aggregate than decompose tasks and their associated data. This suggests that even for generic specialties, specific tasks could be more useful for considering both within and across-system restructuring issues. Aggregation of the specific tasks and associated data relating to functionally similar systems meaningfully into generic tasks, for the purpose of determining the commonality of performance of similar tasks, presents the greater challenge -- a challenge which can be minimized by use of a standard aircraft taxonomy. The aggregation problem is caused by the variations of terminology employed across aircraft to describe similar systems, and is the same kind of aggregation problem that inventory developers encounter in developing generic task descriptors. It should be noted that OSM data only addresses commonality of task performance; it does not provide information about the similarity of knowledge or skills required for performance of tasks that are not coperformed.

In conclusion, both generic and weapon system-specific tasks would appear to be desirable depending upon the classification structuring issue. Any requirement could be satisfied if both kinds of data were available.

Training

There are applications for both generic and weapon system-specific tasks in training decision making and development. Training decision making involves deciding what to train

in initial training for generic specialties where the AFS has responsibility for maintenance of certain systems across the force-wide inventory or subsets of aircraft. Generic tasks can be more useful in this process. Here it is not a question of which aircraft should be the target of training, but which systems and what tasks across aircraft should be trained. With specific tasks, the problem would reside in determining how the separate tasks would be aggregated across aircraft to reach these decisions. Again, an aircraft taxonomy for grouping tasks would be especially useful.

Specific tasks would certainly appear to be more useful for the training developer charged with designing training relevant to a specific aircraft system. Task specificity could be of great value in field, on-the-job, and advanced training.

Specialty Knowledge Test Outlines

As a result of a continuing stream of research by the AFHRL, methodology for developing outlines for Specialty Knowledge Tests (SKT) used in the Weighted Airman Promotion System is being implemented. SKT are intended to include items testing personnel who make up the AFS test population across the requirements of the specialty. One of the more important guidelines for test item development is the accessibility of study reference materials if they are used to supplement Career Development Courses to all personnel to be tested. As a result, test items on specific equipment are generally avoided; tasks that are more generic in nature provide a better test item development source. In fact, according to personnel involved in this research, specific tasks inhibit the capability to produce outlines and in some cases, after-the-fact development of general task statements from tasks that were too specific has been necessary. It seems reasonable to assume that if OSM shifted to the collection of data from specific tasks, some method of aggregating specific tasks and associated data to provide a general base for testing is important.

Weapon System-Specific Task List Requirements

In Table 4, the present organization of weapon-system specific task inventory requirements by AFS is listed. The list does not include specialties maintaining communications-electronic equipment (AFS 30xxx), training equipment (AFS 34xxx), visual equipment (AFS 40xxx), and missiles (AFS 41xxx). These kinds of equipment are normally maintained by a single AFS responsible for all of the systems, thus presenting a much simpler task description process than is required for aircraft maintenance AFSs (see Data Sources for Task List Development, below). The AFS are categorized as maintenance AFSs for which WUC-based specific tasks are inappropriate; AFSs where the primary WUCs are Support General and Inspection Codes; AFSs which cross all on-aircraft systems; AFSs with shreds that may facilitate inventory development; AFSs with a limited number of aircraft or equipment; and off-aircraft equipment AFSs which require access to separate

WUC manuals. How the AFS are distributed is important for assessing the development and data collection strategies for weapon system-specific task lists, particularly from the perspective of present OSM methodology in which task list length is a crucial issue when a single task list is employed to describe all of the work of an AFS.

Review of Table 4 suggests several conclusions relevant to developing WUC-specific tasks.

1. There are six AFS for which there is little or no need for WUC-based task lists. These AFS would appear to be more appropriately described by methods, materials, and processes generic task statements.

2. Job incumbents (crew chiefs) of three AFS with large numbers of aircraft-based shreds normally report work performed under Support General codes (which include Inspection codes). The probability of identifying WUC-based tasks identifying specific equipment is very low. Use of the Support General codes, which are prescribed by MIL-M-38769C (USAF), Manuals, Technical: Work Unit Code, to develop basic task lists for these specialties as well as for use in job inventories for other AFS whose incumbents perform aircraft-general tasks, is warranted.

3. Development of inventories for six AFS which cross **all** aircraft may be anticipated to be the most difficult for generating WUC-based task lists, because there are too many aircraft to produce WUC-based tasks in a single inventory. Some other approach to inventory development and data collection will be imperative to accommodate these AFS.

4. Six AFS have shreds that may facilitate task list development, at least in the sense of covering all of the WUCs and ATCs in a single inventory. Shreds, however, are consistent only through the 5-skill level; shreds disappear or change at higher skill levels. The merging of shreds at the 7-skill level may mean that development of inventories for these AFSs may present the same problem as AFSs which cross all aircraft.

5. Nine AFS cover a limited number of AFS or equipment. These AFS potentially may be easily described in a single inventory.

6. There are six AFSs for which the WUCs reported by incumbents are found in WUC manuals separate from the aircraft WUCs. Access to these separate WUC manuals should be easily obtained. These AFS may be expected to be covered in a single inventory.

Table 4. Weapon System-Specific Task Inventory Requirements
By Air Force Specialty Code

Maintenance AFS for Which Work Unit Code-based Specific Tasks Inappropriate

427X0, Machinist
427X1, Corrosion Control Specialist
427X4, Metals Processing Specialist
427X5, Airframe Repair Specialist
458X1, Nondestructive Inspection Specialist
458X3, Fabrication and Parachute Specialist

AFS Where Primary Work Unit Code is Support General or Inspection

452X4, TAC Aircraft Maintenance Specialist*

A, F-15	G, F-5
B, F-16	H, OV-10
C, F/FB-111	J, T-38
D, F-4	K, T-37, OA-37
E, A-10	L, T-33
F, A-7	Z, All others

*The A, B, and C shreds carry through the 7-skill level; the remaining shreds are combined to form the M shred at the 7-skill level.

457X0, Strategic Aircraft Maintenance Specialist
- A, B-1
- B, B-52
- C, C-18, all C-135, E-3, E-4, VC-25, VC-137
- D, KC-10
- E, SR-71, TR-1, U-2

457X2, Airlift Maintenance Specialist**
- A, C-23, C-130
- B, C-5
- C, C-9, C-20, C-22, C-140, C-141, T-39, T-43

**The B and C shreds carry through the 5-skill level; they are combined at the 7-skill level into a D shred.

AFS Crossing All Aircraft--On-Aircraft Systems

423X0, Electrical Systems Specialist
423X1, Environmental Systems Mechanic
454X2, Egress Systems Mechanic
454X3, Fuel Systems Mechanic
454X4, Pneudraulic Systems Specialist
- A, MAC or SAC Pneudraulic, Hydraulic

457X1, Helicopter Maintenance Mechanic

Table 4. (Continued)

AFS with Shreds that May Facilitate Inventory Development (Some WUCs Will Be In WUC Manual Separate from Aircraft WUCs)

455X1, Guidance and Control System Specialist*
- A, MAC
- B, SAC
- C, TAC

455X2, Communications and Navigation Systems Specialist*
- A, MAC
- B, SAC
- C, TAC

455X3, Weapons Control Specialist*
- A, F-4E/G. AC-130. F-5E
- B, A-7D/K
- C, F-4D

456X1, Electronic Warfare Systems Specialist*
- A, Strategic
- B, Tactical

456X2, Defensive Fire Control Specialist*
- A, AN/ASG-15
- B, AN/ASG-21/AN/ASG-33

462X0, Aircraft Armament System Specialist
- C, A-10
- D, F-4
- E, F-15
- F, F-16
- H, F-111
- J, FB-111
- K, B-52G/H
- L, B-1B
- Z, All others

*Shredded through the 7-skill level; all others through 5-skill level

AFS with Limited Number of Aircraft or Equipment

451X4, F-15 Avionics Test Station and Computer Specialist*
- A, Auto Test Sets
- B, Manual and Electronic Warfare Test Station Console

451X5, F-16, A-10 Avionics Test Station and Computer Specialist

451X6, F/FB-111 Avionics Test Station and Computer Specialist*
- A, Auto Equipment
- B, Manual and Electronic Warfare Equipment

452X1, F-15 Avionics System Specialist*
- A, Attack Control Systems
- B, Instruments and Flight Control Systems
- C, Communication, Navigation, and Penetration Aids Systems

452X2, F-16 Avionics System Specialist*
- A, Attack Control Systems
- B, Instruments and Flight Control Systems
- C, Communication, Navigation, and Penetration Aids Systems

<u>Table 4</u>. (Concluded)

AFS with limited number of aircraft or equipment

452X3, F/FB-111 Avionics System Specialist*
A, Attack Control Systems
B, Instruments and Flight Control Systems
C, Communication, Navigation, and Penetration Aids Systems
455X4, Airborne Warning and Control Radar Specialist
456X0, Bomb-Navigation Systems Specialist
457X3, B-1B Avionics System Specialist*
A, Off, Avionics Systems, CITS, and Doppler Radar Systems
B, Instrument and Flight Control Systems
C, Communication, Navigation, and Penetration Aids Systems
*Shredded through 5-skill level

<u>Off-Aircraft Equipment AFS (Require Separate WUC Manuals)</u>

404X0, Visual Information Equipment Maintenance Specialist
454X0, Aerospace Propulsion Specialist*
A, Jet Engines
B, Turboprop and Turboshaft
454X1, Aerospace Ground Equipment
455X0, Photographic and Sensors Maintenance Specialist*
A, TAC/RECON Electronic Sensors
B, Recon/Electro-optical Sensors
455X5, Avionics Support Equipment Specialist*
A, F/RF-4 {eci;oar
B, A-7/C-5 Avionics
455X6, Airborne Command Post Equipment Specialist

*Shredded through 7-skill level

VI. DATA SOURCES FOR DEVELOPING TASK LISTS

Under the Air Force Maintenance Data Collection System each maintenance action performed on Air Force equipment must be fully and accurately documented [MIL-M-38769C (USAF)]. Standard codes necessary for automatic data processing (such as the WUC and ATC referred to throughout this report) have been developed for recording a variety of data pertaining to the kind of maintenance performed for each kind of equipment.

This section will describe the types of codes available, the basis of their organization, and the implications for developing WUC-based tasks.

Work Unit Code Coverage and Organization

MIL-M-38769C (USAF) prescribes the requirements for the development and preparation of WUC manuals for Air Force equipment. Table 5 displays the categories of equipment for which maintenance data are to be collected and reported. The first two characters of the WUC (the system level) for a given category of equipment maintained are invariant and are the basis for organizing the codes in the manual for any given equipment category. Any deviation must be pre-approved. The table suggests that every classification of equipment for which there is a maintenance AFS is included in MIL-M-38769C (USAF) coverage.

For non-aircraft equipment, WUC for an equipment category is not only invariant but all maintenance is usually performed by a single AFS. For example, for a missile maintenance AFS, each missile maintained by incumbents of that AFS will conform to the WUC specifications. WUCs designating airframe components will be coded at the first two-digit level as 11; wings and pinfolds as 13; liquid rockets as 24, solid rockets as 25, and so on. While the invariance of the aircraft WUCs is absolute, the difference between aircraft maintenance and equipment maintenance specialties is that numerous AFS maintain aircraft but, in most cases, a single specialty maintains <u>all</u> of the systems on the other equipment. Identifying the WUC for construction of WUC-specific tasks to describe the non-aircraft systems is simplified.

For aircraft, the problem is much more complex, because different AFS have different system responsibilities, and each aircraft WUC, except for the standard two-digit aircraft system designation, employs <u>different</u> codes for subsystems and components even though these subsystems and components are similar in function to those on other aircraft. <u>There is, however, a means of reconciling these differences</u>.

Toward A Standard Aircraft Taxonomy

Notice 2, Appendix A, DoD-STD-863B, Preparation of Wiring Data and System Schematic Diagrams, 17 March 1981, provides a basis for cross referencing the variant subsystem and component WUCs. DoD-STD-863B provides a text development key and a system/subsystem/subject numbering (S/S/SN) system that is standard and applied to the development of all aircraft. The system codes in this DoD Standard replicate in a large part the Air Transport Association of America (ATA) Specification 100, <u>Specification for Manufacturer' Technical Data</u>, originally issued on June 1, 1956, and reissued January 15, 1981. Variations between the ATA and DoD specification are limited to the ATA specifications being customized for DoD use in a few places--like

Table 5. Air Force Equipment Work Unit Categories

Aircraft Systems Codes (e.g., Airframe, Hydraulics, Instruments, HF Communications, VHF Communications, Radar Navigation)

Air Launched Missile Systems Codes (e.g., Airframe, Liquid Rocket, Warhead, Flight Controls)

Support Equipment Systems Codes (e.g., Servicing equipment, Handling Equipment, Guidance and Instrumentation, Mission Simulators)

Ground Launched Missile or Spacecraft Systems Codes (e.g., Airframe-Booster Structure, Orbital Craft, Electrical Distribution, Orbital Attitude Maneuvering, Space Ferry and Manned Re-entry Structure)

Support and Real Property Installed Equipment Codes (e.g., Launcher and Launch Facility, Guidance, Tracking Network and Instrumentation, Propellant Loading and storage)

Munitions Systems Codes (e.g., Ammunition, Bombs)

Communication Equipment Systems Codes:

Standard Radar System Codes (e.g., Antenna, Transmitter, Receiver)

Standard Computer System Codes (e.g., Central Processing System, Input-Output System, Interface Systems

Support General Codes (except for Communications Equipment) (e.g., Ground Handling, Servicing, Inspections)

Support General Codes for Communications Electronic Equipment (e.g., Ground Handling, Servicing)

Aircraft Support General Codes (e.g., Look Phase, Isochronal, Special Inspections)

Air Launched Missile Support General Codes (e.g., Look Phase, Special Inspections)

Air Launched Missile Support Equipment Support General Codes (e.g., Look Phase, Special Inspections)

Table 5 (Concluded)

Ground Launched Missile Support General Codes (e.g., Look Phase, Special Inspections)

Non-Nuclear Weapons Support General Codes (e.g., Look Phase, Special Inspections)

Peculiar Munitions Support Equipment Support General Codes (e.g., Look Phase, Special Inspections)

Communications Equipment Support General Codes (e.g., Look Phase, Special Inspections

Support Equipment Support General Codes (e.g., Look Phase, Special Inspections)

Training Equipment Support General Codes

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adding system codes for systems on military aircraft not found on civilian aircraft (e.g., surveillance). The DoD Standard was initially issued in 1977 and is presently undergoing revision.

DoD-STD-863B specifies system and subsystem codes which provide the basis for identifying the WUC for a particular aircraft. Associated with each subsystem code is a narrative description of sub-subsystems that are to be referenced to the subsystem code. For example, the following narrative description is extracted for system code 29-10, Main Hydraulic Power, from Appendix A:

> That portion of the system which is used to store and deliver hydraulic fluid to using systems. Includes items such as tanks, accumulators, valves, pumps, levers, switches, cables, plumbing, wiring, external connectors, etc. Does not include the supply values to the using systems.

Sub-subsystem codes are selected by the manufacturer of an aircraft. These codes, therefore, may vary from aircraft to aircraft and from manufacturer to manufacturer. The only restriction is that the sub-subsystem codes and their titles must conform to the list of items shown in the narrative description of the components of the subsystem.

Examples of system codes (there are a total of 99) and an example of an associated set of subsystem codes are shown in Table 6. The DoD Standard system Codes are not identical to system codes in WUC manuals, but there are one or more easily-accessible tables in WUC manuals that provide for cross-referencing WUCs to the DoD-STD-863B system and subsystem codes.

Table 6. Examples of DoD-STD-863B System Codes

System	Title	System	Title
21	Air Conditioning	39	Electrical/Electronic Panels & Multipurpose-Components
22	Auto Flight		
23	Communications Crew	43	Communications Staff
24	Electrical Power	65	Rotors
29	Hydraulic Power	99	Surveillance
..	....	..	....

Examples of DoD-STD-863B System-Subsystem Codes

System	Title	Sub-System	Title
29	Hydraulic Power	-00	General
		-10	Main
		-20	Auxiliary
		-30	Indicating
99	Surveillance	-10	General
		-20	Data Display
		-30	Recording
		-40	Identification
		-50	Infra-Red Sensors
		-60	Laser Sensors
		-70	Surveillance Radar
		-80	Magnetic Sensors
		-90	Sonal Sensors

Inspection of WUC manuals for the F-15, F-16, and B-1B indicates that appendices are included that provide for cross-referencing WUCs to the system-subsystem codes prescribed by DoD-STD-863B. The WUC manual for the F-15 cross references WUCs to the system-subsystem specified in DoD-STD-863B. The F-16 WUC manual provides a cross reference of WUCs to Reference Designators, whose first three characters (system, subsystem) are identical to the DoD-STD-863B system and subsystem codes. For example, the first two characters of the Reference Designator correspond with the DoD-STD-863B Functional System Number (e.g., 29, Hydraulic Power); the third character corresponds to the DoD-STD-863B Subsystem Number (e.g., 29-1x, Main). The B-1B WUC provides both Reference Designators and S/S/SN from DoD-STD-863B. The preliminary WUC manual for the C-17 cross references S/S/SN to WUCs.

An example of tracing WUCs through Reference Designators to S/S/SN for each of three aircraft is shown below:

Aircraft	WUC	Reference Designator	S/S/SN (DoD-STD-863B)
B-1B	45AAC	2911FPO1	29-10
F-15	45AEC	291016	29-10
F-16	45AAA	2911FP1	29-10

Reference to the DoD Standard system-subsystem codes indicates that Code 29-1 identifies the Main Hydraulic Power system. The WUC and Reference Designator for each of the three aircraft are referenced to the same S/S/SN: 29-10, Main Hydraulic Power. Inspection of the titles for each WUC will show that the equipment is a part of each aircraft's main hydraulic power subsystem.

This referencing system provides the basis for developing, organizing, and aggregating MDCS tasks across aircraft into OSM task inventory form for all weapon systems that are based on the DoD-STD-863B specifications. Furthermore and most importantly, the referencing system will permit the use of computer-based technology to accomplish the WUC linkages fundamental to developing, organizing, and aggregating WUC-specific tasks. At this time, the number of aircraft WUC manuals available for inspection is limited to the B-1B, F-16, F-15, and the C-17. WUC manuals for other aircraft should be reviewed to determine applicability of the DoD Standard provisions.

Assuming that WUCs for other aircraft can be referenced as described, MDCS tasks (ATC plus WUC equipment identification) for a given AFS can be aggregated at the subsystem level. In other words, all of the actions taken on WUC equipment identification items that are a part of each aircraft's Main Hydraulic Power System can be aggregated for all aircraft under a heading such as Maintaining Hydraulic Power Systems in an OSM Job Inventory.

Or, if a Job Inventory for an AFS becomes too long, the subsystem codes and their associated narrative descriptions can be the source of development of generic tasks describing maintenance work performed by incumbents of an AFS across an array of aircraft. There are at least three possible uses of a generic-based task list. First, WUCs for these generic tasks can be identified and precoded for each aircraft at the subsystem code. The precoded aircraft WUC-specific tasks would be accessible for use in analysis after data are collected from job incumbents from the generic tasks. Associated task factor data would only be available for generic tasks if they are the data collection source. The generic data (mean values) would be the basis for estimating WUC-specific task factor data by aircraft. This usage would be analogous to the semantic-assisted analysis technology mapping of MDCS data to OSM tasks and data in which ATCs and WUCs are mapped to OSM tasks, but the

associated task factor data is based on the generic tasks, not WUC-specific tasks. The difference is that SAAT mapping is after-the-fact and is likely to be less precise than the premapping of MDCS data to the generic tasks.

Second, generic tasks can be a second level set of tasks to be used as benchmarks for aggregating task factor data for incumbents across aircraft for Job Inventories containing aircraft WUC-specific tasks. This aggregation would provide incumbent data at a generic level.

Third, generic tasks could be used to describe work performed on a subset of aircraft and WUC-specific tasks used for another subset of aircraft. Such usage could be especially applicable in Job Inventories for AFSs having broad aircraft coverage.

The important point is that DoD-STD-863B provides an aircraft maintenance structure for computer-generated task development and data analysis. First, it is the structure that permits the mapping of WUCs representing the same functional equipment across aircraft; without it considerable effort would be required to create such a structure that is absolutely essential for mapping. Second, the structure provides the potential structure for the analysis of task data from incumbents. It is the common ground for aggregating data for different aircraft as well as the common structure for establishing benchmarking tasks across aircraft. And finally, it provides the structure for developing WUC-specific and generic tasks for use in reducing Inventory length.

Summary

This section considers and amplifies the implications of information in preceding sections for developing WUC-based task lists for OSM Job Inventories, their administration, and the analysis of data from job incumbents.

1. Preliminary tasks based on WUCs and ATCs can be developed for use in Job Inventories covering single and multiple aircraft. These tasks will satisfy the communication and clarity criteria for task description. Areas where precautions must be exercised are in the description of independent tasks and those differentiating among workers. Inventory development specialist intervention will be required to assure tasks are independent and differentiate among workers.

   MDCS-based tasks can be expected to reduce or standardize the various generic tasks presently used to describe similar systems across aircraft. The general tasks now found in OSM Job Inventories can become more consistent in coverage through the use of Support General codes.

2. The present practice of presenting tasks in a single inventory is well founded in terms of providing the same frame of reference for all respondents, even if the practice has meant employing more generic task statements, consistency with present ASCII CODAP processes, analysis flexibility, and application of task difficulty and training emphasis task factor information. Also, computation of composite job descriptions and related data are facilitated.

3. Use of multiple inventories in place of a single inventory for collecting data for an AFS would significantly increase the workload associated with manuscript preparation and quality control during inventory development and mailing, follow-up, data collection quality control, and data reduction.

4. The present single inventory practice for data collection is the most efficient way of providing job incumbents who perform maintenance on several aircraft (such as those assigned to consolidated maintenance organizations) to indicate the full range of their task performance.

In a mail survey, use of separate inventories could be expected to inhibit their opportunity to indicate the full range of task performance. Data on the Uniform Airman Records (UAR) file includes the Program Element Code (PEC) against which each job incumbent is assigned. This information could be included on the mail distribution listing made up from the UAR file to assure that individual job incumbents received a Job Inventory relevant to their PEC. The problem of other aircraft maintained, however, would still remain for mail administration.

One solution to the "other" aircraft maintained by an incumbent identified by PEC is use of a mail presurvey. Incumbents would be surveyed prior to the mailing of the OSM Job Inventory to determine which "other" aircraft they maintain. These data could be integrated in mailing lists obtained from the UAR file to assure that each incumbent receives inventories for each aircraft maintained. Such a system increases OSM workload, and could become administrative, CODAP processing, and CODAP analysis nightmares.

5. Computer administration methods, especially one modelled after computer adaptive testing methods, should eliminate the issue of opportunity to respond to tasks for multiple aircraft issue. Computer administration would permit each respondent to access all of the tasks for each included aircraft. Even without an adaptive system, respondent access to each of the aircraft maintained can be provided by the simple use of background information items about aircraft (or systems) worked on, although a computer adaptive approach should be much more efficient. The technology (equipment, communication media) exists for computer administration following a conventional format, but neither the resources for accomplishing it nor some fundamental issues bearing on electronic

data collection have been investigated. These issues involve legitimate research questions that should be resolved before computer-based data collection is attempted and should be the near-term goal. Successful application of computer data collection should not minimize the pursuit of a longer term goal of developing a computer adaptive methodology. Achievement of the long term goal promises the potential, among others, of methods for minimizing the number of tasks needed to describe a specialty or specialties being surveyed.

6. Use of weapon system-specific tasks in at least some AFSs can be expected to produce task lists that are too long for ASCII CODAP processing. This expectancy suggests that several options for developing WUC-specific tasks, including their use along with generic tasks, will be required. It is anticipated that the length problem will be encountered only for aircraft maintenance specialties. The scope of other non-aircraft maintenance specialties is more limited and in most cases a single AFS has responsibility for a given category of systems. The WUC for these non-aircraft categories of systems provide the structure for developing an inventory for multiple items within a category.

7. Neither mail administration of separate inventories based on aircraft identification nor computer administration can be employed to collect data from task lists that are too long, at least those exceeding ASCII CODAP processing limits. Further, even if the lists are not too long for CODAP processing, consideration of incumbent response load dictates using a mail data collection approach that minimizes the load. Respondent workload can be reduced by use of tracking instructions which would guide respondents to inventory components specific to their job requirements. Incumbents, for example, working on the F-15 would be "tracked" to the F-15 WUC-specific tasks. Incumbents who work on aircraft for which there are no WUC-specific tasks would be "tracked" to the listing of generic tasks describing other aircraft.

8. A clear-cut statement about whether use of one kind of task as opposed to another (WUC-specific v. generic) is preferable can not be asserted. Some users can employ generic-based task data more efficiently; other users can benefit from WUC-specific task data.

9. MIL-M-38769C(USAF) provides information about the WUCs employed for the variety of equipment upon which maintenance is performed and recorded in the MDCS. For non-aircraft equipment, development of WUC-specific tasks should be facilitated. Since a single AFS normally has responsibilityfor all maintenance of equipment items in a given category (e.g., ground-launched missiles, computers), the prescribed WUC for the category should be sufficient for task list development from MDCS data.

10. For maintenance of aircraft, applying a specified WUC structure only at the aircraft system level complicates development of task lists for aircraft maintenance AFS. The structure in itself is insufficient, because of latitude permitted manufacturers in the designation of WUCs below the system or first two character level of the WUC.

11. DoD-STD-863B provides a structure or aircraft system-subsystem taxonomy that, when used in conjunction with a cross reference of Reference Designators to WUCs in the WUC manual for a specified aircraft, can be the basis of a computer-generated system for organizing and aggregating WUCs across aircraft into OSM usable tasks. The DoD Standard creates a system-subsystem taxonomy that opens up a systematic approach to structuring aircraft maintenance task lists that will permit the aggregation of task data collected from job incumbents.

In addition, the narrative descriptions of the content of the sub-subsystem specifications are sources for creating generic tasks useful in several ways. First, these generic tasks could form the task list in Job Inventories covering multiple aircraft and become the basis for the precoding of relevant aircraft WUCs for later retrieval and mapping of aircraft-specific tasks <u>after</u> data collection.

Second, the generic tasks can be used in conjunction with WUC-specific tasks for AFS with broad aircraft responsibility. WUC-specific tasks can be used to describe a designated set of aircraft of special interest and generic tasks used to describe the remainder of the aircraft maintained by an AFS. Such usage assumes an organizational consistency of the complete task list for the AFS, the basis of which resides in the DoD Standard provisions.

Third, and perhaps most important, generic tasks generated from the DoD Standard sub-subsystem narrative descriptions can serve as the set of second level tasks for benchmarking incumbent responses across aircraft. It is unfortunate that sub-subsystem codes are not specified. Without this specification, manufacturers have the latitude to list sub-subsystem or component WUCs as their needs require; thus, an inconsistency of sub-subsystem numbering can exist across the WUC for various aircraft. If the code specifications were complete to the fourth digit, a complete aircraft taxonomy would exist for cross referencing across aircraft.

A review of WUC manuals for the F-15, F-16, and B-1B suggests, however, there is reason to believe that manufacturers may be fairly consistent in identifying similar sub-subsystems by the same code, and to some extent, similar terminology. If this practice is reasonably consistent, which should be revealed by examination of WUC manuals for other aircraft, development and organization of generic tasks into a structure that will facilitate the mapping of individual aircraft WUCs to the generic tasks should be possible.

If such a structure were to be applied consistently during task list development, tasks or task data representing a specific aircraft could be aggregated with tasks from other aircraft under a generic task title; or, data collected from generic tasks (as second level task benchmarks) could be used to aggregate data across aircraft at the generic task level. This aggregation of tasks and the analysis of their associated percent performing and time spent data would be entirely proper.

Further, even if there is insufficient consistency of numbering at the sub-subsystem level to permit computer-based linking procedures based on WUCs, the Semantic-assisted Analysis Technology could provide with little or no SME assistance the linkages of WUC titles with generic tasks generated from the sub-subsystem narrative descriptions. With SME assistance, the system-sub-system taxonomy, if a narrative does not cover all of the items under the sub-system, could be extended to a taxonomy descriptive of all the elements at the sub-sub-system level. Then, since MIL-M-38769C (USAF) provides that WUC equipment identification titles include the <u>noun</u> which describes the equipment, it is reasonable to hypothesize that is feasible for the SAAT to aggregate WUC titles from different aircraft at the noun and adjective level. In fact, some aggregation can be expected to occur naturally, because similar subsystems will have similar names across some of the aircraft (e.g., TACAN transmitter, Inflight Refueling System). The most difficult aspect of SAAT aggregation can be expected to be in the inconsistency of ordering of the WUC nomenclature, that is, the variable practices associated with listing the noun first or modifiers first. Once the WUC titles (at the noun and adjective level) are aggregated, SAAT should efficiently link the titles to the aircraft-structure taxonomy. The end result would be generic and weapon system-specific tasks for data collection, analysis, and reporting. Both kinds of users could be satisfied.

12. The implication of the preceding discussion is that tasks should be developed at two levels, specific and generic, for inclusion in a Job Inventory. In such usage, special attention must be paid to the avoidance of duplicate tasks.

13. Since the Support General Codes (includes Inspection Codes) that precede the WUC for equipment in WUC manuals are established by MIL-M-38769C (USAF), a standard set of general maintenance tasks could be developed for inclusion in each maintenance Job Inventory. The Air Force Standard provides in paragraph 30.2.1 that:

> Support general codes are for recording production credit of repetitive tasks of a general nature and shall not be used for recording malfunctions, repair, NRTS (Note: not reparable this station) or condemnation actions...All support general work must be identified to the most appropriate code. Support general code tasks not applicable to the equipment being coded shall not be included in the manual.

The importance of a standard set of general maintenance tasks is that they, too, can become standards for benchmarking ratings.

The Support General Codes also are a source for developing tasks for crew chief (Aircraft Mechanics) specialties. At the very least, they could form the nucleus of a standard set of tasks across these specialties.

14. Neither the number of WUC-specific aircraft tasks nor of the generic tasks is expected to be so great as to be inhibiting, except when broad AFSs are described. Review of the WUC codes as they apply to a specific AFS for each of three aircraft (F-15, F-16, B-1B) suggests that a relatively small number of tasks will be needed to describe the work of the AFS on a given aircraft. In addition, the DoD Standard system and subsystem taxonomy consists of a small number of elements and the sub-subsystem narratives provide a limited number of categories. If, however, a task list becomes too long, MDCS data, such as frequency of a maintenance action for equipment items, could be used as a screening tool to reduce the number of tasks. Another means of reducing the number of tasks is changing the level of description--from, for example, the fifth character of the WUC to the fourth character. Under current development practices, changes in the level of description frequently occur as a way of reducing task list length.

Conclusions

With regard to providing weapon system-specific task data for various manpower, personnel and training uses, the Semantic-assisted Analysis Technology, with SME assistance to verify and edit mapping of OSM-MDCS data, efficiently maps MDCS task level data to OSM task data from past surveys.

Weapon system-specific tasks based on MDCS data can be computer-generated for use in future OSM surveys. Two levels of task specification are required for data aggregation, data comparability, and limitation of Job Inventory length when AFS are for maintenance of two or more aircraft,

In the final analysis, methods for data collection (i.e., mail v. computer; presurveys; separate inventories) are of lesser importance than the need for an aircraft taxonomy for developing tasks. Computer administration, unless it is an adaptive system, cannot be expected to eliminate problems associated with aggregation of data, comparability of data, or Job Inventory length.

The crucial issues have to do with development of a methodology for linking WUCs from different aircraft, aggregating data across weapon systems, making data from aircraft-specific tasks comparable across aircraft, and regulating the length of Job Inventory task lists.

The issues can be addressed primarily through development of WUC-specific and aircraft-generic tasks in accord with an aircraft structure taxonomy. This structure potentially resides in the specifications of DoD-STD-863B.

The following objectives should guide development and use of inventories of weapon system-specific tasks:

1. Single inventories comprised of all of the tasks performed by a specialty should be used. Their use to collect data should produce generic and specific task data to satisfy the different OSM data users.

2. Use DoD-STD-863B as the basic taxonomy or structure for developing weapon system-specific tasks.

3. From DoD-STD-863B Codes and sub-subsystem narrative descriptions, using SMEs if necessary, generate generic tasks describing work across aircraft.

4. Develop computer software to map WUCs for individual aircraft to DoD-STD-863B system and subsystem codes and sub-subsystem elements.

5. For AFSs that are for maintenance of a single aircraft, generate task lists directly from MDCS data.

6. For AFSs that are for maintenance of two or more aircraft, generate tasks at two levels, WUC-specific and generic, for inclusion in Job Inventories.

VII. RECOMMENDATIONS

This section contains eight recommendations for weapon systems-specific occupational analysis research based upon the research reported in this document.

1. Investigate use of CAMS as a source of WUC-AFS linkage.

2. Develop methods for expanding WUC nomenclature.

3. Investigate methods for improving selection of task-job descriptions for use in SAAT.

4. Investigate use of actual maintenance tapes (v. MDCS B-4 Master File) as source of WUCs for input into SAAT.

5. Investigate sources of expanded WUC equipment identification.

6. Investigate changes in parameters used in SAAT matching to refine list of WUC-task matching provided SMEs.

7. Initiate development of a weapon system-specific task list for an AFS covering multiple aircraft. The task list should include:

   a. Tasks developed from the MDCS maintenance data (v. B-4 Master File).

   b. Tasks developed from the Support General Codes provided in the WUC manuals for each aircraft.

   c. Generic tasks based on the contents of DoD-STD-863B.

8. Initiate investigation of development of equipment-specific task lists from maintenance data reported for other equipment (e.g., communications-electronic, missiles, AGE).

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X. LIST OF ABBREVIATIONS AND ACRONYMS

AF	Air Force
AFHRL	Air Force Human Resources Laboratory
AFS	Air Force Specialty
ASCII CODAP	ASCII Comprehensive Occupational Data Analysis Programs
ATA	Air Transport Association of America
ATC	Action Taken Code
CAMS	Consolidated Aircraft Maintenance System
LCOM	Logistic Composite Model
LSAR	Logistics Support Analysis Record
MDCS	Maintenance Data Collection System
NRTS	Not Reparable This Station
OSM	Occupational Survey Method
PEC	Program Element Code
SAAT	Semantic-assisted Analysis Technology
SME	Subject Matter Expert
SKT	Specialty Knowledge Tests
USAFOMC	United States Occupational Measurement Center
WUC	Work Unit Code